NEW

# PHYSICAL GEOGRAPHY

MONTEITH

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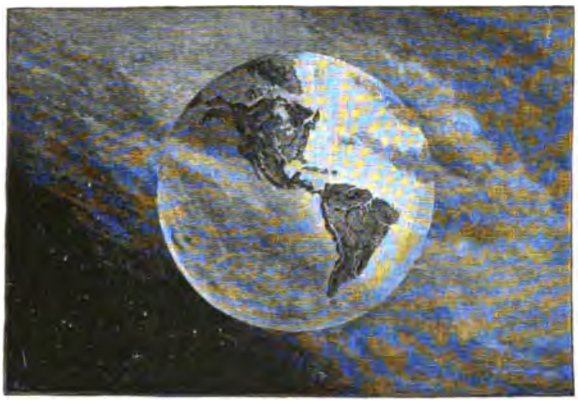
198

# NEW PHYSICAL GEOGRAPHY

FOR

GRAMMAR AND HIGH SCHOOLS, AND COLLEGES



BY JAMES MONTEITH

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NEW YORK ·:· CINCINNATI ·:· CHICAGO

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# MONTEITH'S NEW PHYSICAL GEOGRAPHY.





## PREFACE.

THE attention of Teachers and School Officers is respectfully called to the following special features of this book :—

Its *Easy Style* and the *Clearness of its Statements* fit it for use not only in Grammar Schools, but also in High and Normal Schools.

The *Illustrations*, executed by the best artists, serve not only to embellish the work, but to impress vividly upon the mind of the learner the leading truths in this most interesting science.

The Text contains the latest discoveries in *Physiography*, *Meteorology*, *Hydrography*, *Magnetism*, and *Vulcanology*.

The *Maps* and *Charts* have been compiled from *original sources*, and from the *latest official maps* of the United States and British Governments.

The subject of *Magnetism* contains much new matter never before published, the material having been obtained from the records of the United States Magnetic Observatory by the courtesy of Professor Marcus Baker.

The chapter on *Volcanoes* is based upon the researches of Professor Judd, the highest authority on the subject of Vulcanology.

The subject of *Ocean Currents* contains the latest discoveries, including those made by Commander Bartlett, of the U. S. Steamer Blake.

The chapter on *Rivers and Drainage* contains much that is new in the way of Hydrography. The facts and figures have been obtained from the records of the U. S. Engineer Corps.

The subject of *Winds* is based upon the researches of Professor Ferrel; that of *Storms*, upon the records of the United States Weather Bureau. The latter subject is the most complete exposition of the Law of Storms that has yet appeared in a school text-book. It contains new and important principles.

It is the only Physical Geography containing *Bird's-eye Relief Maps*.

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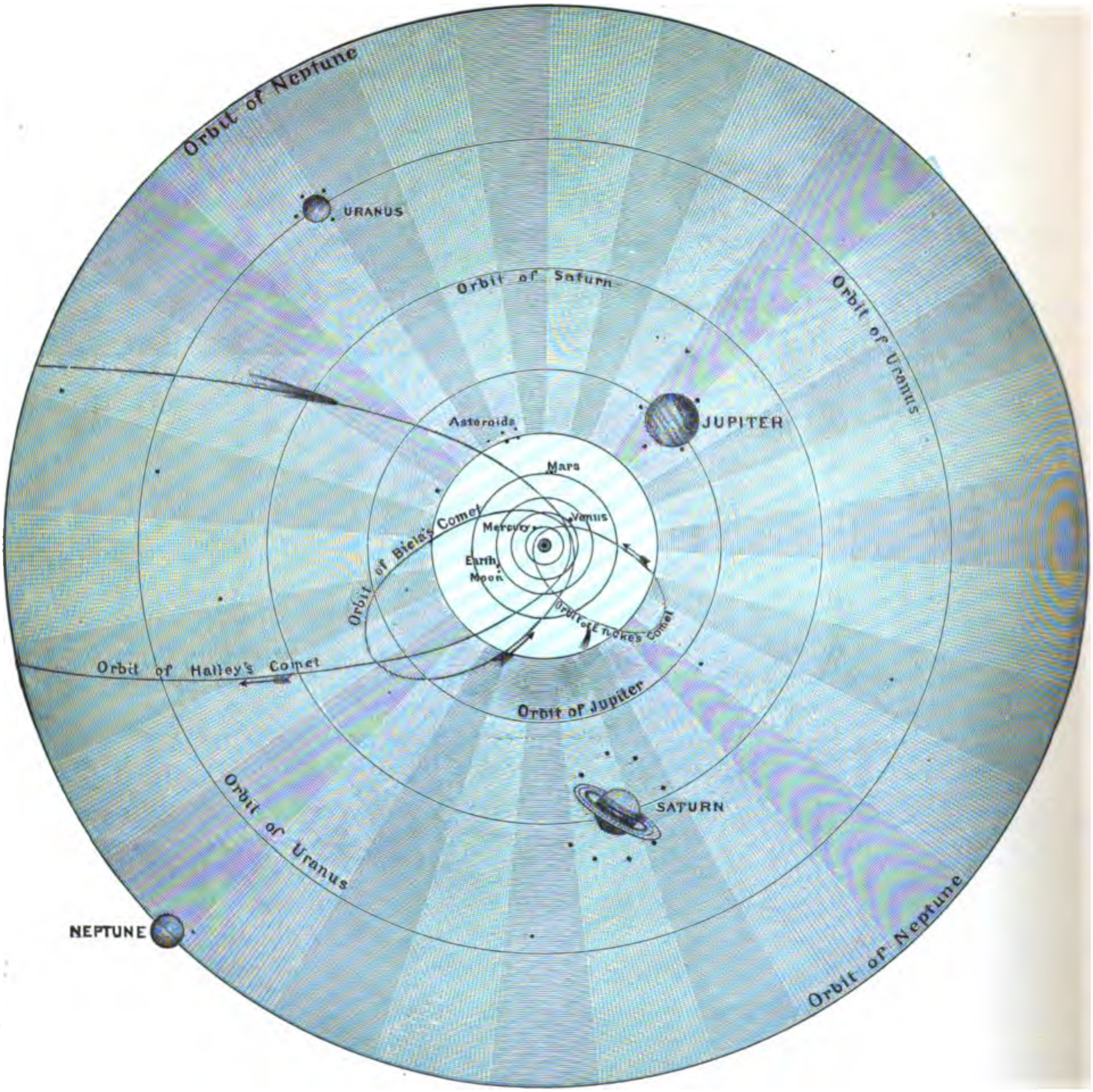



# THE SOLAR SYSTEM.

*A diagram showing the paths and relative size of the various members of the Solar System.*
*The space included within this* **Orbit of Jupiter** *represents the proportionate size of the* **Sun.**

# PHYSICAL GEOGRAPHY.

## CHAPTER I.

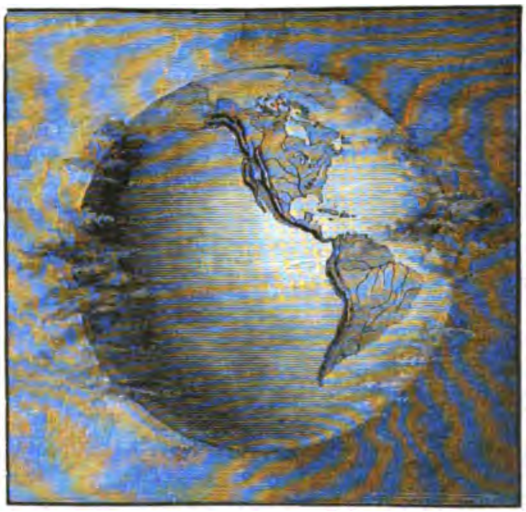
### THE EARTH IN SPACE.

1. **Stars.**—Those bright, twinkling points of light that we see in the sky after the Sun has gone down, are huge balls of matter.

2. All of them are very far away, and some are so distant that a ray of light, moving 186,000 miles every second, would not reach the earth for many years after starting on its journey.[1]

3. Nearly all of these heavenly bodies are many times hotter than the hottest furnace-fire—so hot, indeed, that they exist either as molten matter or else as a vapor.[2]

4. A few of these balls of matter are constantly changing their position in the sky. They no longer give light of their own, but we see them because the light of the sun falls on them, and is reflected to our eyes.



The Earth in Space.

5. They are called planets (from a Greek word meaning *wanderer*), and they are forever whirling round and round the Sun.

6. **The Earth is one of these Planets.**

7. **Fixed Stars.**—The Sun gives both light and heat to the family of planets whirling around him. The other bright bodies are called fixed stars.

8. All of the other *Fixed Stars* are suns, and there are many reasons for believing that each has a family of worlds or planets revolving about it.

---

[1] The nearest fixed star, excepting the Sun, is star $\underset{=}{a}$ of the constellation Centaurus. Its light is three and one quarter years in reaching the Earth.

[2] Every substance exists in at least two of three states—solid, liquid, or vapor. By heating iron it melts, and finally boils, giving off an orange-brown vapor or steam. Water may be easily changed to ice or to steam. By withdrawing the heat, and at the same time applying great pressure, the air we breathe has been liquefied.

9. Our Sun and his group of worlds are called **The Solar System.**

10. **The Solar System** is composed of the Sun, eight worlds called *planets*, twenty or more satellites or moons, and about 240 smaller planets called asteroids, besides comets and meteors.[1]

### THE SOLAR SYSTEM.

| MEMBERS OF SYSTEM. | DISTANCE FROM SUN, IN MILES. | MOVES AROUND SUN ONCE IN | DIAMETER, IN MILES. | NO. OF MOONS. |
|---|---|---|---|---|
| **SUN** | ............ | ............ | 860,000 | ....... |
| **Mercury** | 35,750,000 | 88 days. | 2,992 | 0 |
| **Venus** | 66,750,000 | 224 days. | 7,660 | 0 |
| **Earth** | 92,300,000 | 1 y. | 7,918 | 1 |
| **Mars** | 141,000,000 | 1.9 y. | 4,211 | 2 |
| **Asteroids** | ............ | ............ | ........ | ....... |
| **Jupiter** | 480,000,000 | 11.8 y. | 86,000 | 5 |
| **Saturn** | 881,000,000 | 29.5 y. | 70,500 | 8 |
| **Uranus** (*ū'ra-nus*) | 1,771,000,000 | 84 y. | 31,700 | 4 |
| **Neptune** | 2,775,000,000 | 164.8 y. | 34,500 | 1 |

11. Between Mars and Jupiter are about 240 small planets, called asteroids. They are very small, none exceeding 300 miles in diameter.

12. Since the year 1600, more than 200 comets have been discovered.

13. A few comets belong to the Solar system, and travel around the Sun very much as the planets do. Others came from regions in space of which we have no knowledge, and after passing partly around the Sun, went off into space, never to return.

14. **Meteors** are commonly called shooting stars. They may be seen on almost any clear night, darting like balls of fire across the sky.[2]

15. **The planets** in their order from the Sun, are named as follows: Mercury, Venus, Earth, Mars, the Asteroids, Jupiter, Saturn, Uranus, and Neptune.

16. The line in the diagram on which each planet is situated shows its path around the Sun.

17. All of the planets move around the Sun from west to east.

18. Their orbits or paths are ellipses, the Sun being at one focus or center.

19. Each of the planets turns on its axis from west to east.

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[1] The velocity of meteors is about forty miles per second. Moving with such a great velocity, when meteors strike the Earth's atmosphere, the great heat developed not only melts, but vaporizes all but the largest ones. Many fall to the Earth and are found. Some are composed chiefly of iron and nickel. Others are of the nature of stone. At least one comet (Tempel's) has been proved to consist of an immense swarm of meteors moving in a cluster around the Sun.

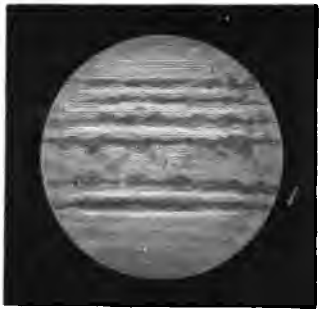
[2] It is usual, but hardly correct, to say that the planets revolve about the Sun. The truth is that all of the members of the Solar System revolve about a common center of gravity.

20. The Earth and each planet beyond it are attended by one or more moons.

21. Each moon moves around its planet in an elliptical path from west to east.

22. So far as known, each moon turns on its axis from west to east.

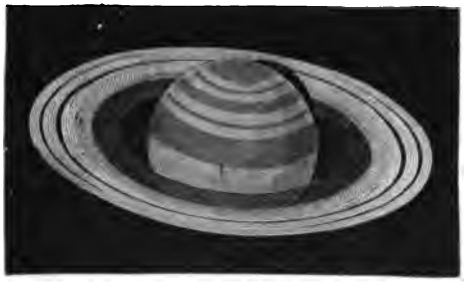
23. The Earth, and probably the other planets, are composed of the same elements that are found in the Sun.[1] Of many meteors that have been analyzed, none has been found which contains elements other than those which compose the Earth.


Telescopic View of Jupiter.

24. Thus it will be seen that the planets, in many respects, resemble one another.[2]

25. They differ widely in their physical condition, however. Some are apparently hot and fluid, while others are cold and solid.

26. **Jupiter** is still glowing with heat, and possibly gives a faint light to its five moons. It is enveloped by dense clouds forming the bands or zones, which are seen in the picture.


Telescopic View of Saturn.

27. **Saturn** is surrounded by several flat rings, one outside of another, whirling swiftly around as though they were the rims of immense fiery wheels. It is thought that Saturn is a world yet in the process of formation, and that the matter composing this planet is partly fluid and partly solid.

28. **Mars** is a world very much like our own. Its surface is diversified with oceans, seas, bays, continents, islands, and peninsulas. Through a good telescope one may see the frozen zones of ice and snow, one at the north, the other at the south pole. Its position, with respect to the Sun, is such that the temperate zones of Mars have seasons like ours.

29. **The Moon.**—At least one of these heavenly bodies, the moon, has become cold from surface to center. The air and water, if ever there were any, have disappeared. Its surface is covered with immense craters, many of which exceed fifty miles in diameter. During the hottest part of the moon's day, the temperature is nearly that of melting lead; at night, it is thought to be about 200° below zero.

30. **The Sun.**—The Sun is a huge mass of matter more than 1,250,000 times greater than

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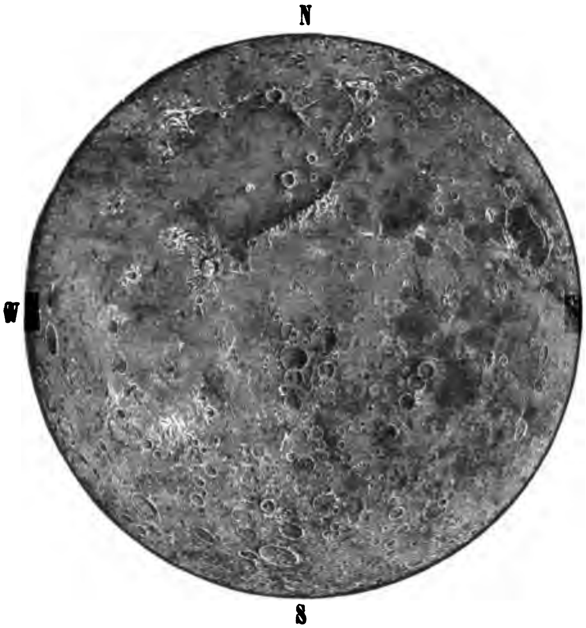
[1] This has been discovered by analyzing the light of the Sun with the spectroscope. Sodium, potassium, iron, nickel, hydrogen, and many other elements have been discovered in the Sun, and most of them also occur in several fixed stars.

[2] It is thought by many students of nature, that all of the matter which composes the solar system was originally in one mass of vapor; that this matter began to gather around a center; that a rotation around this center was acquired; that the mass of revolving vapor grew smaller in bulk as it cooled; that finally, the rotation became so rapid that portions of the mass were thrown off; that these portions, collecting in globular masses, formed the planets; and that the planets, by a similar process, threw off still smaller portions, which became moons. Although this is a supposition only, yet there are many facts which make it worthy of belief.



Telescopic view of Moon.

the Earth. The spectroscope shows that it is composed of substances similar to those found in the Earth and the other planets.

31. These substances, however, owing to the intense heat, are at the surface, in a gaseous or a fluid state.

32. With a powerful telescope, jets of gas at a white heat may be seen projected to a distance of even 200,000 miles. The velocity with which these immense columns of gas are thrown upward, sometimes exceeds 250 miles per second.

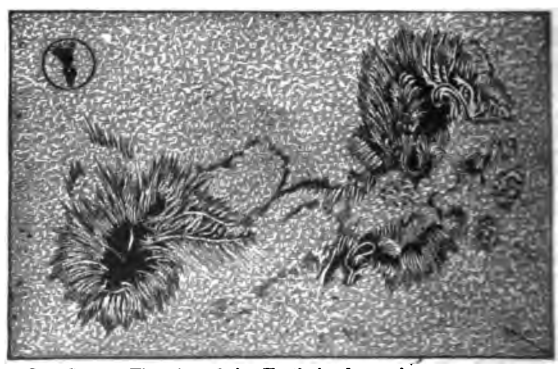
33. Sometimes, funnel-shaped, black spots are seen on the Sun's surface. These spots have exceeded 140,000 miles in diameter. They are usually in violent agitation. Indeed, the whole surface of the Sun appears to be a tempestuous sea of white-hot metallic vapors, and seething, molten elements.

34. **In shape,** the **Earth** is a slightly flattened sphere, bulging at the Equator.[1] This has been shown in various ways.

35. Ships have sailed around it. The Earth's shadow is circular. A straight line surveyed at the surface of the water apparently rises. In reality, the surface of the Earth curves away from the line.

36. **The Dimensions of the Earth** are as follows :—

Diameter at the poles, 7899.2 miles.
Diameter at the equator, 7925.6 miles.
Circumference at the equator, 24,899 miles.
Surface, 197,000,000 square miles.
Volume, 260,000,000,000 cubic miles.


Sun Spot. The size of the Earth is shown in one corner.

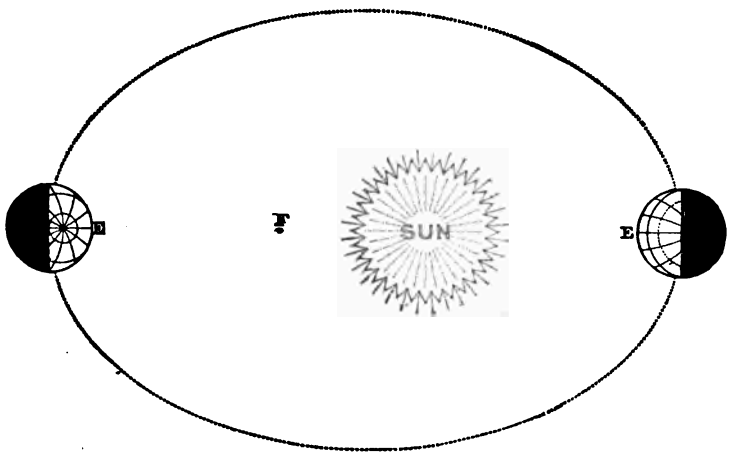
37. **The Earth weighs** about five times as much as a globe of water of the same size. Its density, therefore, is said to be 5. At the surface, however, the density is only about 2½; that is, a cubic foot of matter composing the surface is only 2½ times as heavy as the same bulk of water.

38. Hence it is thought that either the matter in the interior of the earth is compressed, or else that it is composed of metallic substances.

[1] In mathematics, such a solid is called an oblate spheroid. The Earth is not a true oblate spheroid, however, as recent investigations have shown that there is also a slight bulging at the temperate zones. This "square-shouldered" appearance is also noticeable in Saturn and Jupiter.

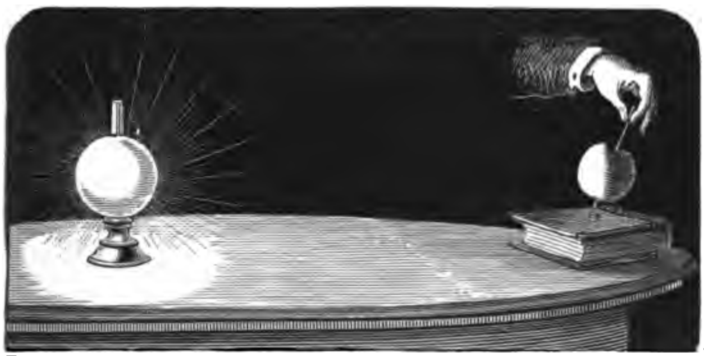
39. The pupil who studies the rocks that compose the surface of the Earth will continually find fresh proofs that the whole Earth was once at a glowing white heat.[1]

40. **Motions.**—There is nothing at rest in the Universe. Suns, moons, and planets are constantly whirling about their common center, and all are at the same time sweeping on through space. The stars, too, are in swift motion, each in his own path, never for a moment resting.




An ellipse, representing a distorted view of the Earth's orbit. E is the Earth; F is one focus of the ellipse; the Sun is at the other. The Earth is 3,000,000 miles nearer the Sun at perihelion, than six months later.

41. **The Earth has two motions.** First, it turns on its axis, causing day and night.[2] Second, it moves rapidly around the sun, making the complete journey in about 365¼ days.[3]



The Succession of Day and Night. The lamp represents the Sun; the apple, the Earth; the needle on which the apple turns represents the Axis of the Earth.

42. When nearest the Sun, the Earth is said to be in **perihelion;** when farthest from the Sun, in **aphelion.**

43. The Earth reaches its perihelion about January 1st and its aphelion, six months later. Its motion is most rapid while in perihelion.

44. The axis of the Earth is inclined 23½ degrees toward the ecliptic, as may be seen in the diagram at the top of the next page.

[1] Although the temperature of the Earth's interior is far above the melting point of the most refractory substances, it is by no means certain that it is in a "fluid" condition. On the contrary, the Earth, with respect to the Sun's attraction, behaves like a solid body.

[2] The time required by the Earth to make a complete revolution is divided for convenience into twenty-four hours. At the equator, the circumference of the Earth is nearly 25,000 miles, but the parallels decrease rapidly in length as they approach the poles. It is evident, therefore, that the velocity diminishes as the latitude increases, being greatest at the equator.

In latitude 0°, the velocity is 1,040 miles per hour; in latitude 30°, 896 miles; in latitude 50°, 665 miles; in latitude 70°, 354 miles; in latitude 80°, 180 miles; and at the poles, it is 0.

[3] The length of this journey around the sun is about 580,000,000 miles. This divided by 365¼ × 24 gives a quotient of about 66,000 miles, the Earth's velocity in miles per hour. The velocity in one second is nearly 19 miles.

There is one other motion of the Earth, which, in great lengths of time, is thought to modify its climate. The poles of the Earth are constantly moving around in a circle, in the same manner as does the upper pole of a sleeping top. This movement is completed in 27,000 years.


The Earth's orbit as it would appear if viewed on a level with the Ecliptic, or plane of the orbit.

45. From the illustration on the preceding page, you will see that the Earth is nearest the Sun during the winter of the Northern Hemisphere, where most of the land is situated.

46. The effect of this is not only to temper the extreme heat of summer, but also to moderate the cold of winter in this hemisphere.

47. In respect to its distance from the Sun, the inclination of its axis, and its velocity, the Earth seems better adapted than any other planet for the sustenance of life.[1]

## WHAT HAS BEEN TAUGHT IN CHAPTER I.

***The stars are great masses of intensely hot matter many million miles away.***

***The nearest fixed star is the Sun.***

***The Sun is attended by eight planets and about 240 asteroids that are continually whirling about it.***

***There are also comets, some of which are a part of the solar system, and innumerable meteors or shooting stars.***

***Most of the planets have cooled and no longer give any light, but others are thought to be still in a fluid condition, and perhaps to emit a faint light.***

***All the planets are like the Sun in shape, and they resemble one another in their motions and general properties.***

***All but two of them are attended by moons or satellites, having form and motions like the planets themselves.***

***Most, if not all of the planets are surrounded by an atmosphere.***

***The motions of each planet are principally a spinning upon its axis and a whirling around the Sun.***

***The Earth measures about 25,000 miles in circumference, and nearly 8,000 miles in diameter. Its distance from the Sun is nearly 93,000,000 miles.***

***It spins on its axis about 365 times while it moves around the Sun once.***

***The first of these is the cause of the succession of day and night, the second causes the change of seasons.***[2]

***In its journey around the Sun, the Earth moves at the rate of 66,000 miles per hour.***

***The path of the Earth is an ellipse, the Sun being at one of its foci or centers.***

***The Earth is about 3,000,000 miles nearer the Sun in winter than in summer.***

[1] We shall learn in chapters following, that life-forms have played an important part in the history of the world. Many of the rocks have been formed through their agency; the present aspect of the Earth's surface is largely owing to the work of plant and animal life. We need go only a few miles, either above or below the Earth's surface, to find conditions of cold or of heat that would at once be fatal to any form of life with which we are acquainted. Yet, through all the changes and convulsions of nature, life-forms have not only held their place, but they have also steadily progressed to higher and more complex stages. [2] The change of seasons is caused by the revolution of the Earth around the Sun, together with the inclination of the Earth's axis in the same general direction, throughout the year.

# CHAPTER II.

## THE CRUST OF THE EARTH.

1. It is thought that the Earth was once a seething, molten mass, and that through the course of long periods of time, the surface gradually cooled, until a solid crust formed on the outside.[1]

2. The *thickness* of the cooled crust of the Earth is estimated at from 55 miles to 250 miles. There are at the present time, however, no means whereby it may be measured with any certainty.

3. **Condition of Interior.**—That the interior of the Earth is intensely hot, there is little or no doubt—a fact which may be shown by several phenomena.

4. First, the **shape of the Earth,** slightly flattened at the poles, is such as would be produced by the spinning of a partly fluid body on its axis.

5. Second, **active volcanoes** are found in all parts of the world. These throw large quantities of melted matter from their craters.

6. Third, in sinking **deep shafts** and artesian wells, there is a gradual increase of temperature, averaging 1° F. for about 53 feet.[2]

7. Fourth, **geysers and hot springs** occur at various latitudes in every continent. The waters of these springs sink deep into the Earth through crevices and passages. When they return to the surface, these waters are heated nearly or quite to the boiling point. Hence they derive their heat from the Earth's interior.[3]

8. **Formative Processes.**—The student who studies the crust of the Earth will readily believe that long periods of time have elapsed since the Earth took its present form.

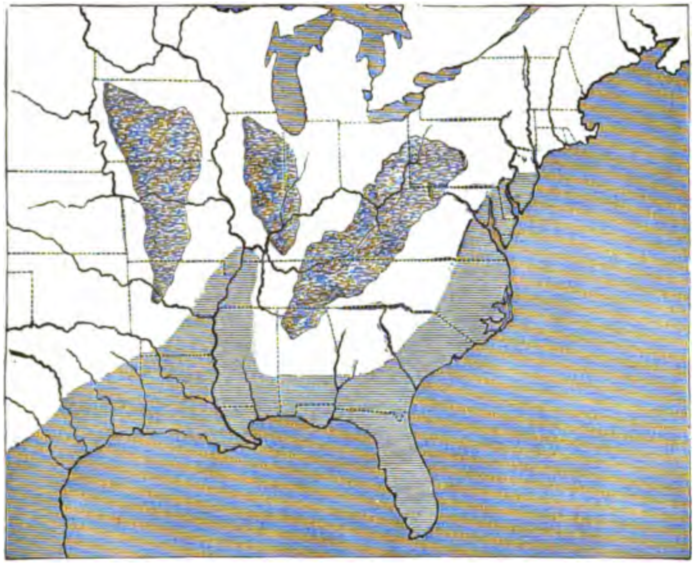
---

[1] Whether or not the interior of the Earth is in a *fluid* condition, is as yet a matter of speculation. The stronger evidence certainly leads to the conclusion that the Earth is *solid*, or else *plastic*, from center to surface. Many mathematicians are of the opinion that the great pressure from the outside towards the center—that is, the enormous weight of the overlying crust—causes the heated interior to retain a condition of rigid solidity.

[2] This increase in temperature is by no means uniform, but varies between 27 and 198 feet per degree. The rate of increase is greater in mines than in artesian wells. In many instances, the rate of increase is very largely due to the heat resulting from chemical decomposition. For instance, in the deep shafts of the Nevada silver mines, the temperature, on the same levels of different mines, varies from 10° to 60°. Beyond a depth of 2,000 feet, the average rate of increase is 1° for every 165 feet.

The thickness of the Earth's crust cannot be estimated from these figures, however, as the melting point of solids varies with the pressure—the greater the pressure, the higher the melting temperature. Besides, the crust of the Earth has never been penetrated more than one mile in depth, and it cannot be told whether or not the increase of temperature is the same for all depths.

[3] In many instances, however, hot springs derive their heat from the chemical changes going on among the rocks.



The parts of the map shown in white represent the first land of the United States. The parts in dark shading along the coasts remained under water until a more recent period.
The dark shading inland were vast tracts of marsh and woodland, but now they are the great coal fields of this country.

9. Nearly, if not all, of the dry land has been again and again covered by the waters of the sea, and we may also believe that what is now the bed of the ocean has been more than once lifted above the surface of the waters.

10. **Plant life** in the greatest luxuriance, and most wonderful in form and size, has covered the face of Earth and has been overwhelmed by the waters.

11. **Gigantic animals** lived, multiplied, and perished. Enormous reptiles inhabited the immense swamps and morasses which, during different periods, covered large areas of the Earth's surface. These perished, and were succeeded by other forms of life, and these, in turn, passed away, leaving the story of their lives printed upon the rocks.

12. **Different climates** succeeded one another. Parts of the Earth, at one period covered with ferns, palms, and other tropical plants, were afterwards buried under the ice and snow of a dreary winter that for centuries chilled the Earth's surface.

13. **Immense glaciers,** or rivers of ice, have rounded off the sharp hilltops and mountain sides, and have ploughed deep gorges through the hardest rock.

14. **Earthquakes and upheavals** have raised large surfaces of land out of the waters, and in other places, have sunk great areas until the sea covered them many fathoms deep.

15. **Volcanoes and fissures** have poured out floods of lava until immense areas of territory have been covered to a great depth.[1]

16. **Running waters** have worn their way through these sheets of lava and other rock, cutting channels, sometimes exceeding a mile in depth, into the mountains and plateaus.

**The wind,** blowing loose sand and dirt day after day and year after year, has filled up seas, and in some cases has severed arms of the sea from the main body of water. Often it has extended the shore for miles into the sea.[2]

17. **These changes,** carved in the rocks by the forces of nature, have been going on for ages. No one can measure the time in years; it can be measured only in periods of unknown length.

[1] One of the most remarkable lava floods is that of the northwestern portion of the United States. It covers an area of about 200,000 square miles in Oregon and Washington. This sheet of lava, where the Columbia river has cut through it, is nearly 4,000 feet thick.—*Le Conte.*

[2] At Pescadero, California, an ancient sea beach, has been found two and a half miles inland from the present shore. The whole intervening area has been filled by sand driven before the wind.

18. **Rocks.**—By the term **rock,** is meant anything that enters into the structure of the Earth's crust. Sand, clay, gravel, granite, limestone and slate are all classed as rocks.

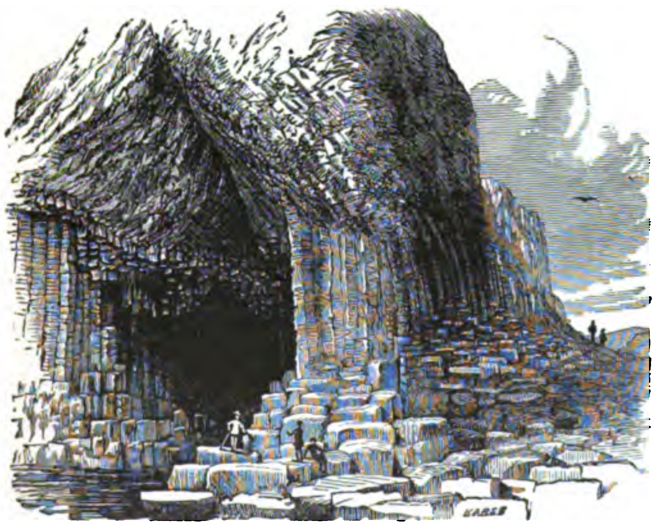
19. For the convenience of students, rocks are classified in several different ways. The following are the most commonly mentioned :

**Igneous** or **Unstratified,** and **Aqueous** or **Stratified.**
**Fossiliferous,**
**Metamorphic,**
**Primary, Secondary, Tertiary, Etc.**

20. **Igneous rocks** are those which have been formed by the action of **heat.** They are usually (except lavas) found in dikes or irregular veins. Frequently, they have a glassy lustre. Lava, pumice-stone (volcanic froth), and trap-rock are examples. Igneous rocks are unstratified.[1]

21. **Aqueous[2] rocks** are formed out of the sediments that have been deposited by water. They are usually soft, and have a clayey appearance. Aqueous rocks are always stratified. Sandstones, limestones, claystones, and slates are examples.

Work of Waves. Fjord in Norway.



Igneous Rocks. Fingal's Cave.

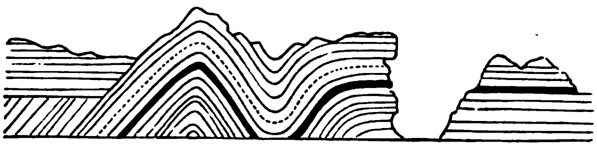
22. **Stratified[3] rocks** are of aqueous origin. They are so called because they appear in sheet-like masses called *strata,* each *stratum* having a uniform thickness. Stratified rocks may usually be split into thin sheets or layers.[4]

[1] The teacher should procure good specimens of each rock mentioned. Typical specimens may be purchased for a small sum of money. In many localities they may be found in large quantities. In mountainous countries, it will frequently happen that all the rocks here described may be found near the school house.

[2] *Aqueous,* from the Latin, *aqua,* water ; hence, rocks formed by the action of water.

[3] *Stratified,* from the Latin, *stratum,* a layer ; hence, rocks arranged in layers.

[4] The thin layers into which stratified rock may sometimes be split are called *laminæ.* Not all stratified rock is capable of being thus split up.



Stratified Rock.

23. **Slate, soft coal,** many sandstones, and shales are examples of stratified rocks.

24. **Unstratified rocks** do not occur in layers. They are rocks of igneous origin.[1]

25. **Aqueous rocks** are frequently called sediments, or sedimentary rocks.

26. The **fine mud** which running water often contains is called *silt*. The Missouri and the Sacramento river hold in suspension, large quantities of silt.

27. **Metamorphic[2] rocks** are thought to be sediments, which, under great pressure, have been changed by the combined action of heat and water, until they resemble igneous rocks.

28. Metamorphic rocks are generally composed of **crystals,** irregularly cemented together. Sometimes they appear to have been partly melted. *Gneiss, clayslates,* and *marble* are examples.[3]

29. **Fossiliferous rocks** are stratified rocks which contain the casts or "petrified bodies" of animals or of vegetable growths.

30. In **limestone,** the stone form of the animal or plant appears as though it had been cast in a mould.

31. In **sandstone,** however, usually the print or impression only, is found.

32. Among these **imprints** and **casts,** are found the tracks of reptiles and **birds,** the stony skeletons of huge animals, and the delicately drawn pictures of leaves and insects.[4]

33. **Stratification.**—Except where igneous rock has been thrust to the surface, the surface of the continents is covered with sedimentary or aqueous rocks.

34. The various strata were, at first, in **horizontal layers**; but on account of the contraction of the Earth's crust in cooling, they are frequently in an oblique position. Sometimes they occur in folds, and often they are greatly crumpled and broken.

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[1] "Beds of mud, clay, or sand may often be traced, by insensible gradations, into shales and sandstones. In many places, the process of consolidation is going on before our eyes. . . . . Thus, the sediments of the Rhine are now consolidating into hard stone, and, on the coast of Florida and Cuba, comminuted shell and corals are quickly cemented into solid rock."—*La Conte.*

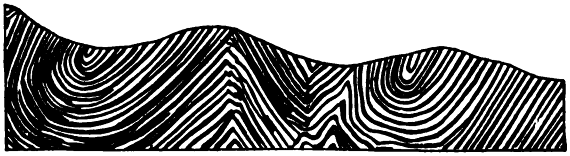
Pupils living on the sea shore, may sometimes see the process of stratified rock making. The water of an incoming tide is loaded with mud and ooze. At the turning of the tide, the mud and ooze sink to the bottom, and as the tide slowly recedes, are baked and hardened by the sun. The next incoming tide bears a fresh deposit of mud, which, in turn hardens. Shellfish are frequently caught between layers, and birds sometimes run over the fresh, soft surface. Both shellfish and bird-tracks are covered by the next deposit which the tide bears. Thus, a permanent record is made, which may be read ages hence.

[2] *Metamorphic,* from a Greek word meaning *change* or *transformation.*

[3] *Granite* is also classed among metamorphic rocks. The minerals composing granite are *mica, feldspar,* and *quartz.* Whenever granite is stratified or laminated, it is called *gneiss.* If the feldspar is wanting, it is *mica schist.* If the mica is replaced by hornblende, the rock is then called *syenite.*

*Sandstone* is composed of small grains of sand cemented together by lime, magnesia, or by oxide of iron. The brown stone of New York is a sandstone of the latter class. Sandstones are frequently metamorphic.

[4] These casts are usually called "petrified" remains or bodies. The substance itself does not turn to stone; it is gradually absorbed, and the cavity is, at the same time, filled from the surrounding rock.

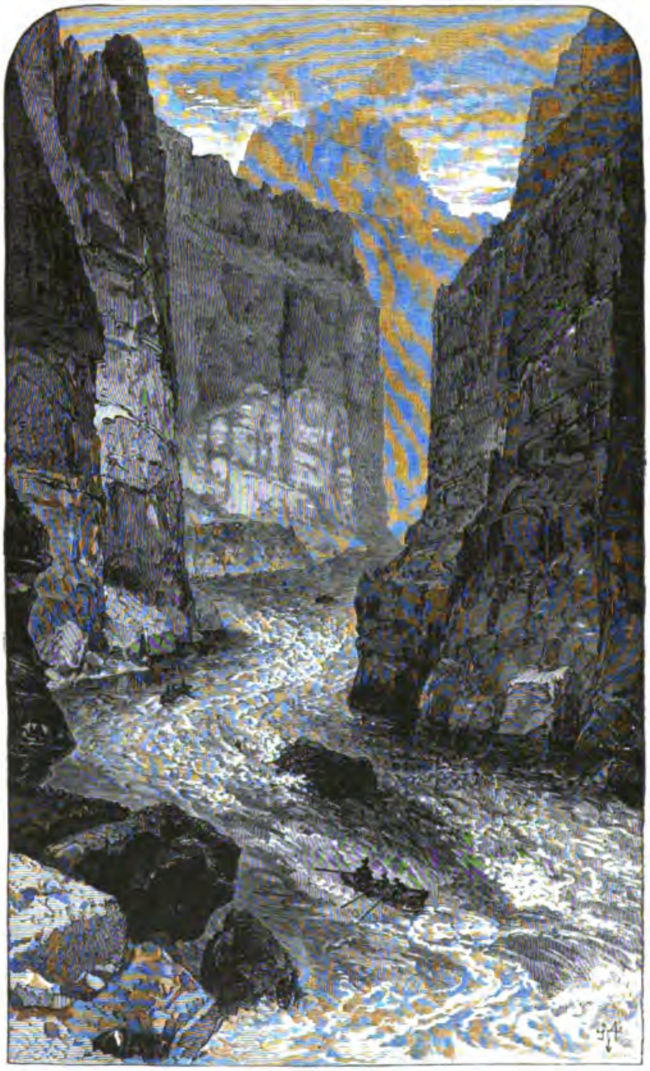


Strata folded by Side Pressure.

35. In some localities, where strata have been **tilted,** or turned with their edges upward, fresh layers of aqueous rock have been deposited on the upturned edges of the first. Strata in this position are said to be unconformable.

36. The process by which the edges of strata have been laid bare through natural causes, is called **erosion.**

37. It is in this way that the book of the world's history has been opened so that the story may be read from its pages. Each stratum is a chapter in the story of the world, and the student will at once see why we begin to read at the lowest.



Erosion.—Work of Rivers.

38. It is not always easy to determine the relative position of strata at a distance from each other. It has taken many years to learn the little that is already known.

39. Now, the position of strata can generally be told by the fossils contained within them, and the different groups of strata are named from the character of the fossil plants and animals they contain.

40. Thus, the rock *lowest* in relative position is called the rock of the *Azoic* (without life) *era.*[1]

41. **Order of Strata.**—Upon this is found the rocks of *Palæozoic* (early life) *era.* Then comes the *Mesozoic* (middle life) *era.* Next above is the *Cenozoic* (new life) *era.* Last of all is the era in which **man** appeared on the Earth.

42. On page 16 the pupil will see the arrangement of the various ages as they occur. Each age is subdivided into periods and epochs.[2]

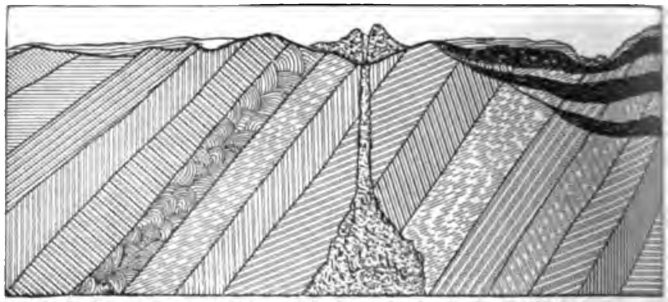
43. **Azoic Life.**—In the *Azoic era,* no forms of life are with certainty known to exist. It is thought, however, that life of some kind, probably vegetable, had appeared even then.

[1] Fossil remains have recently been found in Azoic rocks.

[2] The series of strata is never found *complete* in any one place, as it appears in the table. In one locality, the Azoic rocks are found at the surface; in another, secondary; in still another, tertiary, or perhaps secondary. The relative position was first determined by noticing the overlapping of the edges. Now the geologist can determine the age or the period by the *character of the fossils.*

| ERA. | AGE. | PERIOD. |
|---|---|---|
| PSYCHOZOIC. | AGE OF MAN. | |
| CENOZOIC ERA. | AGE OF MAMMALS. | |
| MESOZOIC ERA. | AGE OF REPTILES. | |
| PALAEOZOIC ERA. | CARBONIFEROUS: AGE OF COAL PLANTS AND AMPHIBIANS. | |
| | DEVONIAN: AGE OF FISHES. | |
| | SILURIAN: AGE OF SHELL FISH, SPONGES AND CORALS. | |
| EOZOIC OR AZOIC ERA. | FIRST FORMS OF LIFE. | |

Order of Strata.

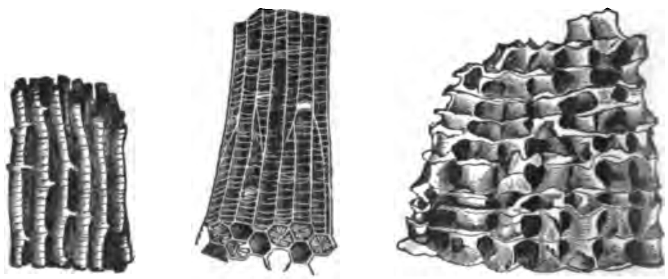


Showing rocks of different periods at the surface.

44. **Palæozoic Life.**—In the lower strata of the Palæozoic era, there are found a few sponge-like animals. These had no special form, and were nothing but jelly-like substances, having neither limbs, head, nor digestive organs.

45. **Silurian Life.**—Above these strata in the Palæozoic time are found the rocks of the

46. **Silurian Age,** or the *age of shell-fish.* Of these, there were a great many species.



Fossil Coral.

47. **Corals, sponges,** and star fish were abundant. The sponges of the Silurian **age** were more highly developed than those of the previous time. A few mosses and lichens existed.

48. **Devonian Life.**—The Devonian age succeeded the Silurian. This is the *age of fishes,* during which, for about the first time, an animal having a backbone appears on the Earth.

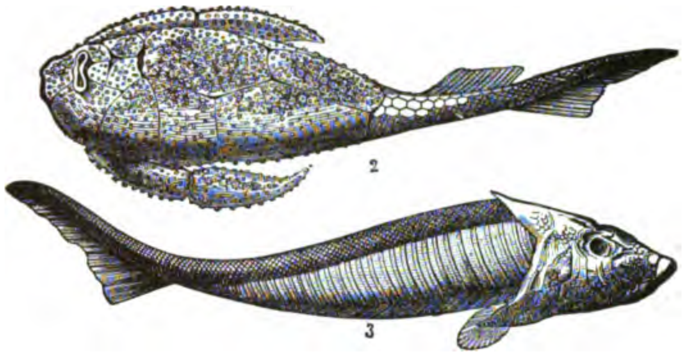
49. **Shell-fish** were still abundant, and they were also of a higher type. Corals were less plentiful.

50. **Land plants** and forest trees thrived, and, for the first time, insects existed. The Devonian age passed almost insensibly into the

51. **Carboniferous Age,** the period when **coal** plants and **amphibious**[1] animals began their existence. The coal plants, which included horse-tails, tree ferns, and reeds of enormous size, were the chief feature of this age.

[1] Amphibious animals are those that live equally well either on land or in water.

Silurian Shell-fish.




Devonian Fish.

52. These plants flourished, died, and were covered by the sediments of successive floods, till, in some localities, the various strata of coal exceed *two miles* in thickness.

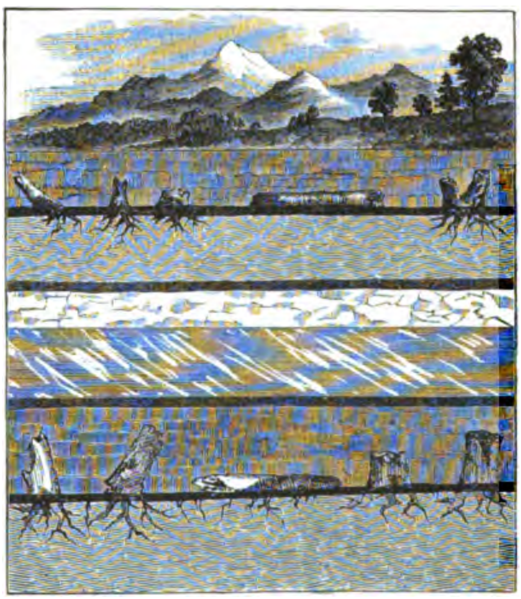
53. **Reptiles** began to appear during this age. Fish, shell-fish, corals, and insects also abounded.

54. The **climate** of the Carboniferous age was moist and tropical.

55. **Mesozoic Life.**—The Mesozoic era occurred at the close of the Carboniferous age.

56. **Enormous lizard-like reptiles,** crocodiles, and turtles were the principal life-characteristics of this era. A few pouched animals appeared at the close.

57. **Birds,** for the first time, appeared. A few species of these are remarkable for their having, instead of beaks, jaws set with socket teeth.

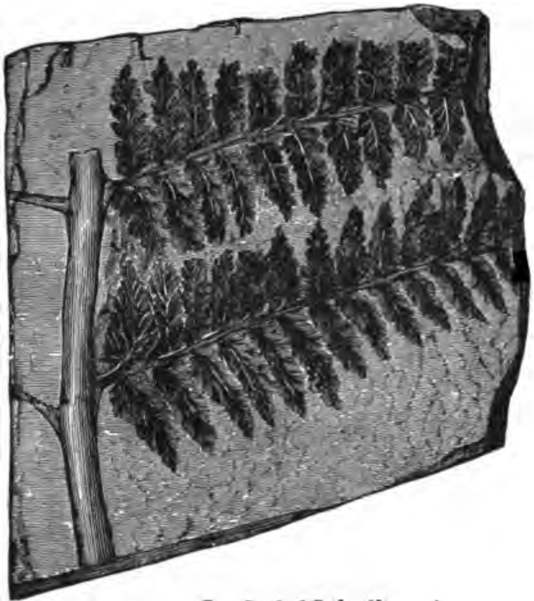



The Coal Seams of the Carboniferous Age.

58. **Cenozoic Life.**—The Cenozoic era, which followed, is the period in which mammals[1] were the ruling type of animals. The animals of this era appeared on the Earth with apparent suddenness, and in great numbers.

59. In the **Bad Lands,** the plains of Colorado, and other great burial grounds of animal remains, are found the fossil bones of the elephant, the rhinoceros, the horse, the wolf, the deer, and many other kinds.

[1] Mammals—animals which suckle their young.



Fern Leaf of Carboniferous Age.

Leaflet enlarged.

60. **Before the dawn** of this era, all of the species of gigantic reptiles had perished. They were replaced by smaller species of crocodiles, turtles, snakes, and frogs.

61. **Europe** and **North America**, at this time, were regions of perpetual summer. A profusion of tropical plants flourished, and tropical animals in multitudes lived and covered the Earth.

62. **More than 1,500 species** of **insects** have been found in the rocks of the Cenozoic era. Ants, bees, wasps, and butterflies of various kinds are found in great numbers.

63. **Glacial Epoch.**—About the middle of this era, a change of climate throughout the whole northern hemisphere occurred, and the tropical climate that had lasted so many ages, gave place to one of icy coldness.

64. Thus was ushered in the great Glacial epoch. During this epoch, North America and Europe were scored in every direction by glaciers which grated over the surface of these continents.

65. The sharp tops of the mountains were rounded off, cañons and ravines were cut deep into the rocks, and the plains were covered to a great depth by loose drift scraped off the mountain sides.

66. With the coming of the Glacial epoch, large numbers of animal species disappeared from the face of the Earth. There survived, however, the cave bear, the cave lion, the horse, the reindeer, and the wolf.

Reptiles of Cenozoic Era.

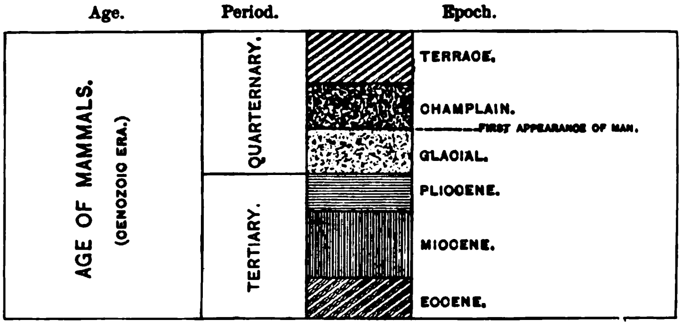
67. **Age of Man.**—At last appeared the crowning glory of the history of creation—**Man.** With his coming, the reign of brute force that had held sway so many ages, ended.

68. In the **bone caverns** of Belgium, Germany, and Italy, skeletons of human beings are found with the bones of *extinct animals.* Scattered about the cavern are rude weapons and implements of the chase. These caverns are covered up with limestone, over which are gravel and drift many feet deep.[1]

[1] In England, flint implements associated with the broken and hacked bones of extinct animals, are found *above* the Glacial epoch, and *under* the gravel beds of the Champlain epoch.

"Only a few years ago an almost perfect skeleton of a Palæolithic man was found in a cave at Mentone, France. I

69. From the few scraps of **unwritten history** which he has left, primitive man seems to have been a savage of the lowest type. He lived in caves, and eked out an existence by fishing and hunting. He neither cultivated the soil, nor did he have any domestic animals.




70. In the preceding brief history, the student will not fail to notice that each succeeding age has brought forth higher and better developed forms of life than those of a preceding period.

71. **Improvement** and **progression** have been the law of creation. Each succeeding chapter of the story sheds a greater glory upon the Great Architect of the Universe, whose wisdom and power know neither beginning nor ending.

## WHAT HAS BEEN TAUGHT IN CHAPTER II.

***The Earth was once a molten mass of matter, on the surface of which a solid crust formed.***

***That the interior of the Earth is yet intensely hot.***

***The internal heat is shown by volcanoes, hot springs, and the increase of temperature towards the center.***

***That various forms of animal and plant life have appeared and disappeared.***

***That the whole surface of the Earth has been changed by the action of water, and also by volcanic action.***

***The story of these great changes has been recorded in the rocks.***

***Rocks are classified as stratified or aqueous, unstratified or igneous, metamorphic, and fossiliferous.***

***Stratified or aqueous rocks are formed by the action of water; they occur in layers or strata.***

***Unstratified or igneous rocks are formed by the fusion of the substances composing the Earth.***

***Metamorphic rocks are aqueous or sedimentary rocks, changed by the combined action of heat, pressure, and water.***

***Aqueous rocks generally, and metamorphic rocks sometimes, contain the casts or the imprints of animals and plants.***

***In the lowest rocks, the Azoic, few forms of life appear.***

***In the Palæozoic era, which followed, sponge-like animals, corals, shell-fish, and fish having backbones, appeared in succession.***

***In the latter part of this era, huge amphibians and the vegetation which formed most of our coal fields, thrived in great abundance.***

***The Mesozoic era, which followed, is noted for the great number of gigantic reptiles, the prevailing types of life during that period.***

***In the Cenozoic era, which succeeded, mammals were the prevailing type of life.***

***That man first appeared just after the close of this era.***

***Each age has produced higher forms of life than those of the ages preceding it.***

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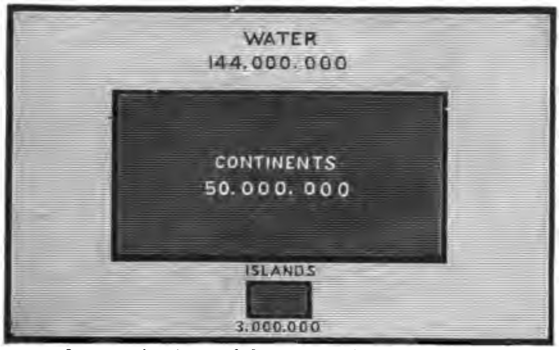
is that of a well-formed man with an average sized skull, and a facial angle of 85°. The antiquity of this man is undoubted, for his bones are associated with those of the cave lion, cave bear, rhinoceros, and reindeer, together with those of living species. The bones of the skeleton are all in place, surrounded with the implements of the chase (flint implements) and the spoils of the chase, viz., the bones of the reindeer, *perforated* teeth of stag, etc. Of the latter, 22 lay about his head. These are supposed to have been worn as a chaplet. This Quaternary man seems to have laid himself quietly down in his cave house and died."—*Le Conte.*

# CHAPTER III.

## THE LAND SURFACE OF THE EARTH.




Comparative Areas of Oceans, Continents, and Islands.

1. **Extent.**—The surface of the Earth covers an area of about 197,000,000 square miles. Of this area 144,000,000 are water, and the remaining 53,000,000 square miles, land.

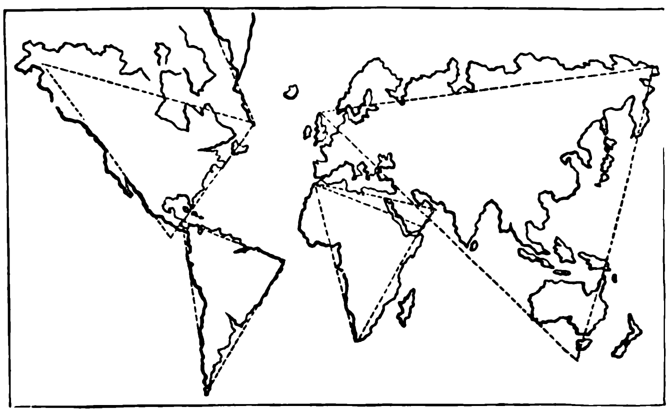
2. **The land surface** of the Earth consists of several large bodies of irregular shape, called continents, together with a large number of islands.

3. **The islands** have an aggregate area of 3,000,000 square miles.

4. **Shape.**—These land masses have each a triangular shape, broad at the north and tapering to a point at the south. They form the six continents.

5. **Position.**—The largest continents are crowded about the North Pole, stretching southward in three directions. The three northern lie almost wholly in the North Temperate, and the three southern, in the Torrid zone.

6. Taking the north of France as a center, a great circle will divide the Earth into two hemispheres, the northern one of which contains nearly all the land. A point southeast of New Zealand is the center of the water hemisphere.



The general form of each of the land divisions is that of a triangle, the apex pointing toward the south.

7. The land surface may be separated into two divisions, which lie on opposite sides of the Earth. For convenience, the two halves of the Earth are called the *Eastern* and the *Western Hemisphere.*

8. **The Eastern Hemisphere** contains the continents of Europe, Asia, Africa, and Australia, together with a large number of islands. It contains nearly two-thirds of the entire land surface.

9. **The Western Hemisphere** contains the continents of North America and South America, together with many islands.

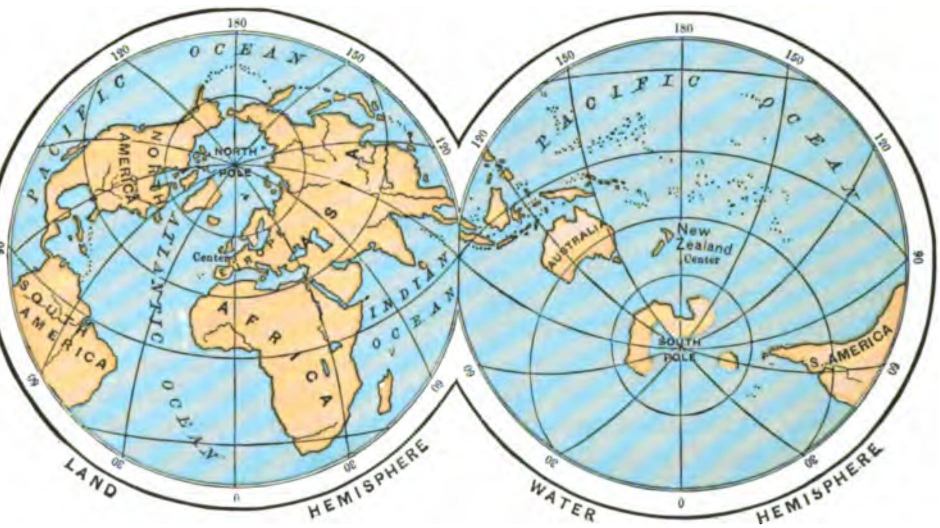
10. **Coast Lines.**—Of the six continents, the northern group of three is bounded by a very irregular coast line. This irregular coast forms a great number of bays, gulfs, and peninsulas.


Relative Size of the Continents, in Square Miles.

11. **Such indented coasts** are of the greatest importance to the people inhabiting a continent, because the existence of a large number of good harbors, more than any other cause, promotes a diffusion of industries, knowledge, and civilization. They also modify and temper the climate of a country, increasing its fertility and productiveness.

12. The accompanying table shows the relative length of coast to continental areas :

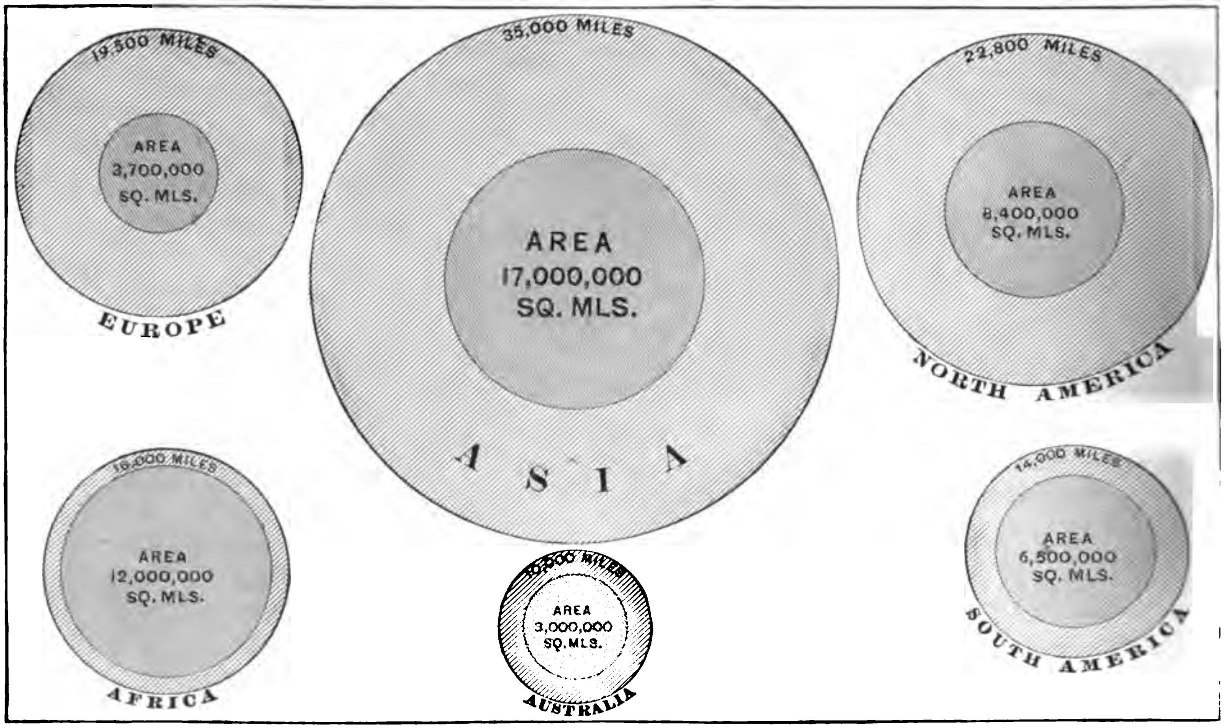
| CONTINENTS. | AREA. | COAST LINE. | SQ. M. FOR 1 M. OF C'ST. |
|---|---|---|---|
| **Asia**............... | 17,000,000 | 35,000 | 500 |
| **Africa**............. | 12,000,000 | 16,000 | 750 |
| **North America**.. | 8,400,000 | 22,800 | 368 |
| **South America**... | 6,500,000 | 14,500 | 449 |
| **Europe**............ | 3,700,000 | 19,500 | 190 |
| **Australia**......... | 3,000,000 | 10,000 | 300 |




The Distribution of Land and Water.

13. It will be noticed by this comparison that Europe ranks first, and Africa last. It might truthfully be said that the intellectual and commercial importance of a continent depends directly upon the comparative length of its coast line.

14. **Surface.**—Continents are not plain, level surfaces. They are diversified with mountains and valleys, plains and rolling hills, table-lands and lake-beds, rugged hills, ravines, and winding rivers.




Length of Coast compared with Area. The circumference of the outer circle represents the length of the coast line.

15. **Mountains** appear in *ranges,* which are usually of great length.

16. **A mountain chain** or **system** consists of several parallel ranges. Thus, the Alleghany, the Blue, and the Cumberland range of mountains, together, form the *Appalachian system.*

17. **The principal mountain system** of a continent is generally near the coast.

18. **Plateaus** are high elevations of land which cover large areas. Plateaus of small area, having level tops, are called table-lands.

19. **Plains** are low, level surfaces, usually having an extensive area.[1]

20. The arrangement of these land features with reference to one another, affects not only the drainage of continents, but also the climate, the commercial industries, and the productions of the soil. Hence, the surfaces of the continents must be carefully studied.

21. **Eastern Hemisphere.**—The Eastern Hemisphere extends from Bering[2] Strait, on the northeast, to Cape Verd, on the southwest. The continents of Europe and Asia form one united body of land. Africa is naturally a peninsula, joined to Asia.

22. **Its chief system of mountains** and highlands extends nearly the whole distance from the northeast to the southwest.

23. From the highest parts of this system, the surface slopes toward the surrounding waters. The northern slope is gentle ; the southern, abrupt.

24. **Western Hemisphere.**—The Western Hemisphere is composed of two triangular masses of land joined by an isthmus. It extends nearly north and south, having a slight inclination toward the northwest.

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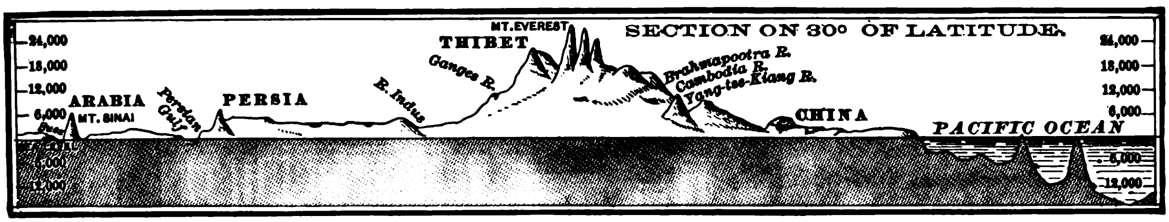
[1] By common consent, land surfaces having an elevation exceeding 1,500 or 2,000 feet are called plateaus ; those having a less elevation are plains. [2] Bering, or Behring. The former is now used by the best authorities.

A Mountain Chain.—Highest peak.—Volcano.—Table land, or plateau.—Lakes at different elevations.—Glacier, ending in a waterfall, which, with outlet of upper lake, forms the river.

25. **The mountain system** of the Western Hemisphere extends from Bering Strait to Cape Horn. On the western side, the slope is abrupt; on the eastern, it is gradual, being interrupted by low ranges of mountains near the Atlantic ocean.[1]

26. **Asia.**—Asia is the largest of the six continents. The Himalaya, together with several parallel ranges, forms the great mountain system and the main axis of the continent. Mt. Everest, whose altitude is 29,000 feet, is the highest point.




Profile of Asia.

27. **The great plateaus** of Asia are inclosed by these mountains. Arabia and western Hindostan are also vast plateaus.

28. **The plains** of Asia are north of the mountain system. They slope gently toward the Arctic ocean. There are smaller plains on the borders of the Caspian sea, in the eastern part of China, and in western Hindostan.

29. **Asia is drained** by a number of large rivers flowing from the slopes of the mountains into the surrounding waters.

30. The Caspian sea, the sea of Aral, and the basin of the Dead Sea are below the ocean level.

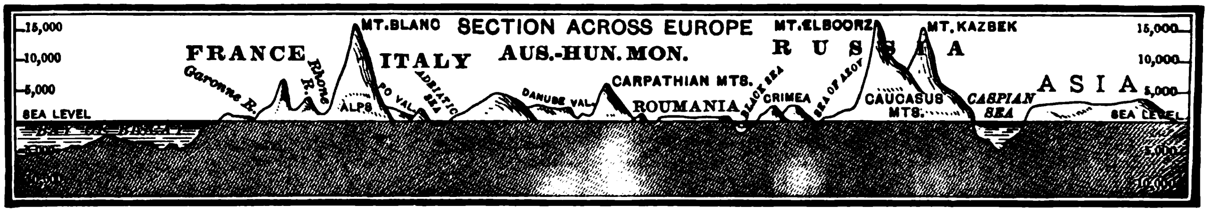
31. **Six large peninsulas** on the eastern and the southern side are formed by mountain ranges and plateaus extending into ocean waters.

[1] In the capitalization of proper names, the plan followed is the same as that of The American Cyclopedia.

32. **Several chains of islands,** formed by partly submerged mountain ranges, lie near the eastern and southeastern shores of the continent.

33. **Europe.**—Europe joins Asia, the Ural mountains being the natural boundary.

34. **The mountain systems** of Europe partly inclose the continent. The chief of these are the Scandinavian, Ural, and Alpine chains, the last system being the principal system.




Profile of Europe.

35. From this system, the Austrian Alps and the Pindus extend into the Mediterranean sea, forming the peninsula of Turkey and Greece. The Apennine mountains, in a like manner, form the peninsula of Italy; and the Scandinavian mountains, the peninsula of Norway and Sweden.

36. The highest point in the Alps is Mt. Blanc, 15,800 feet high. Mt. Elboorz, in the Caucasus (*cau'ca-sus*) mountains, has an altitude of 17,000 feet.

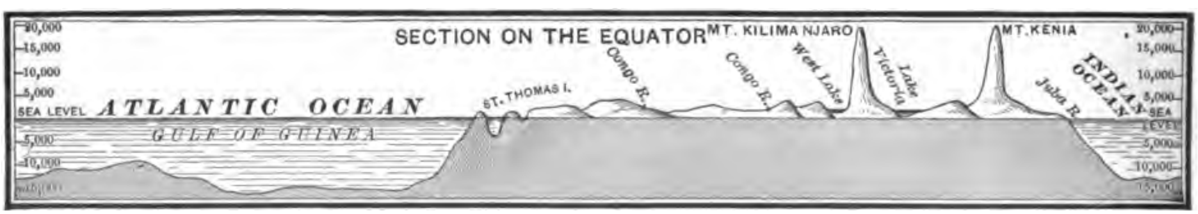
37. The largest plateau is the Spanish or Iberian peninsula. Central and southern Europe consists almost wholly of plateaus traversed by river valleys.

38. **The plains** of Europe lie in the northern and northeastern part. The great Russian plain covers about one-half of Europe. Northern Germany, the Netherlands (Holland), western France, and a part of Belgium are embraced in this plain.[1]

39. **Europe is drained** by a great number of rivers rising in one or another of the three general elevations. Those of the Russian plain rise in the Valdai Hills or on the slopes of the Ural mountains. The others rise chiefly in the Alpine mountain system, or else in the Scandinavian mountains.

40. **Africa.**—Africa is an immense plateau, taking its shape from the mountains and the abrupt slopes that form its coast.

41. **The chief mountain range** is on the eastern side of the continent. The Kong mountains form the western; and the Atlas mountains, a portion of the northern border.[2]




Profile of Africa.

[1] A portion of Holland lies below the sea level, and is protected from the encroachment of the sea by means of dikes.

[2] The Crystal, Cameroons, and Mocambe ranges are a continuation of the Kong mountains. The sharp bend of this mountain chain forms the Gulf of Guinea.

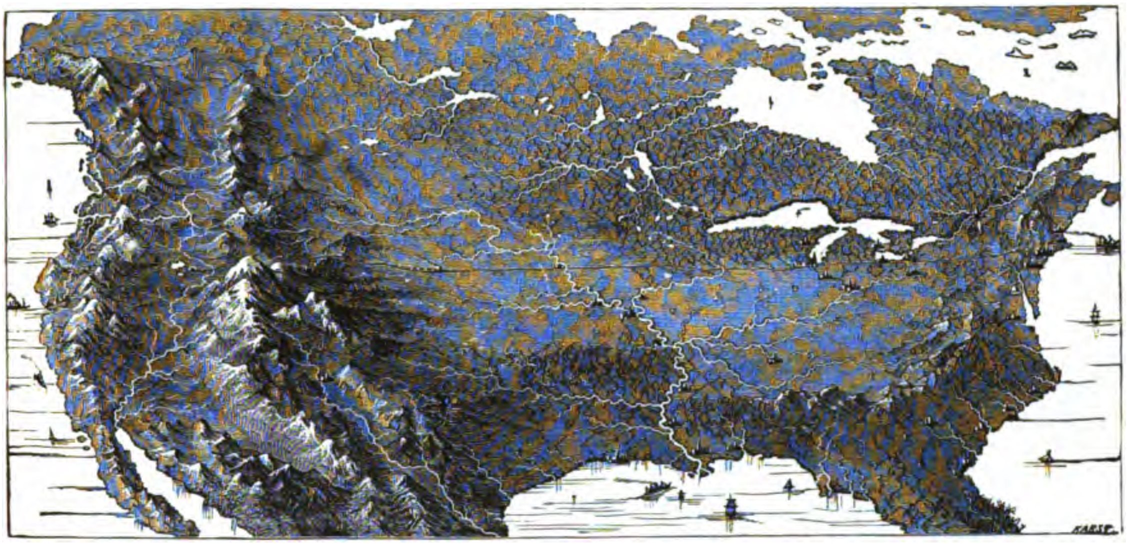
42. The highest points of land are Mts. Kenia, about 20,000 feet, and Kilima Njaro, about 18,500 feet in height.

43. The southern half of the African plateau has an average elevation of 5,000 feet; the northern half, about 1,500 feet.

44. Southeast of the center is an elevated basin over 6,000 feet above the sea level. This basin contains several large lakes, which are the sources of the great river systems of the continent.[1]

45. A small portion of the Sahara, south of Tunis, is from 100 to 300 feet below the sea level.

46. **North America.**—North America is an immense plain, bordered on the west and southwest by the bold and rugged Rocky mountain system, and on the east by the low parallel ranges which constitute the Appalachian system.



Bird's-eye View, or Relief Map of a part of North America.

47. **The Rocky mountains are the main axis** of the continent. Parallel to these is a chain of mountain ranges consisting of the Cascade, the Sierra Nevada, and several shorter ranges, each having an altitude of about 8,000 feet.

48. The highest points are Mt. St. Elias, 19,500 feet; Mt. Popocatepetl, 18,500 feet; and Mt. Whitney, 15,086 feet. There are forty peaks, each over 10,000 feet high, in this system.

49. In the eastern part of the continent is the **Appalachian system,** consisting of several low parallel ranges, forming an angle of 45° with the main axis.

50. **The great plateaus** of North America lie between the parallel ranges of the Rocky mountain system. The most important of these are the plateau of Mexico and the Great Basin.

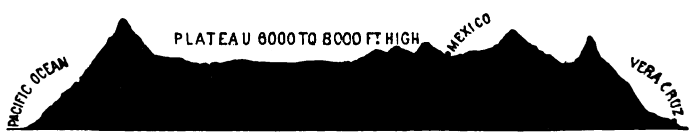
[1] The Zambeze, the Livingstone, and the Niger have cut their channels through deep mountain-passes in order to reach the sea.

Sierra Nevada Mts. Wasatch Mts. Rocky Mts.

Bird's-eye View of the Great Central Basin.

51. **The Great Central Plain** lies between these mountain systems. The highest part of this plain is called the Height of Land. It lies near the northern boundary of the United States, and forms one of the principal continental watersheds. Although it is traversed by low ranges of hills, it is neither mountainous nor generally rugged.

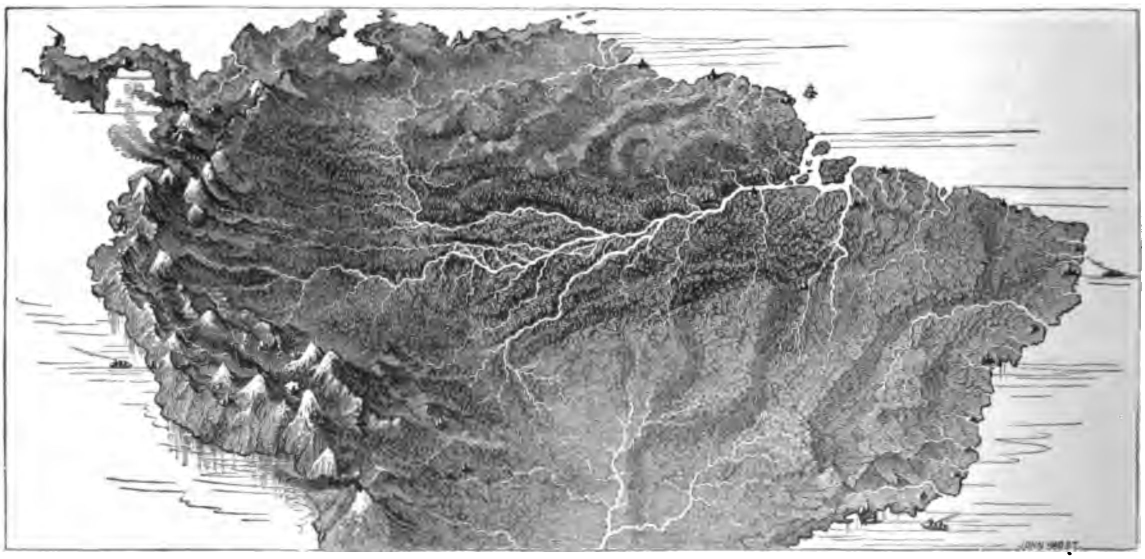
52. **The Great Lakes,** situated at the summit of the Height of Land, constitute the largest body of fresh water in the world.[1]




Section of Mexico from the Pacific Ocean to the Gulf of Mexico.

53. **The drainage** of North America is more complete than that of any other continent, the principal drainage areas being the Arctic slope, the Gulf slope, the Great Basin, the Atlantic slope, and the Pacific slope.

54. **Several remarkable depressions** exist in the Pacific Highlands. Death Valley and the Sink of the Mojave (*mo-hah'vĕ*) river in California, are the principal ones. The former is about 420, and the latter 350 feet below the sea level.

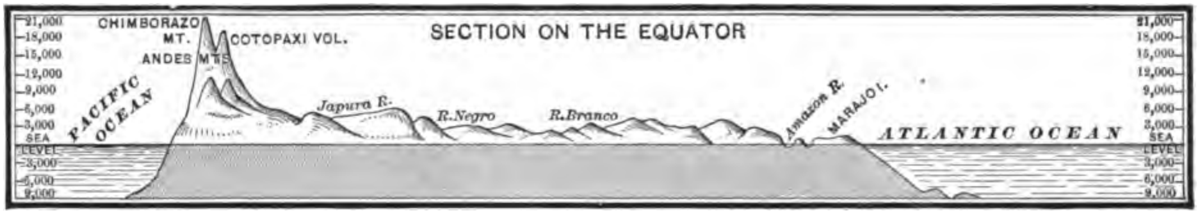


Bird's-eye View of a part of South America.

[1] The summit of the Height of Land may be traced by drawing a line on the map, between the sources of the tributaries of the Mississippi and the sources of those rivers whose waters flow into the Arctic ocean. Also draw a line inclosing the tributaries of the Great Lakes. This will separate the Arctic slope, the Gulf slope, and the valley of the St. Lawrence river.


Bird's-eye View of the Mississippi Valley.

55. **South America.**—South America is triangular in shape, and broadest at the north. Like North America, it is an immense plain bordered by a high mountain system on the west and a low one on the east. The Height of Land in the center forms two principal slopes, one to the north and the other to the south. The crest is so level that the Cassiquiare river divides, sending part of its waters to a tributary of the Amazon, and part to the Orinoco river.




Profile of South America.

56. **The Andes mountains,** which are a continuation of the Rocky mountain system, form the main axis. In the Andes mountains are more than fifteen peaks, each over 16,000 feet high.

57. These mountains extend in two principal ranges, between which are a number of large plateaus.

58. The Brazilian system of mountains lies on the eastern side of the continent, and forms an angle of about 45° with the Andean system.

59. **The great plains** of the Orinoco and the Amazon are in the northern and northeastern part. The less extensive pampas of the La Plata are in the southeastern part.

60. **Australia.**—Australia, in its continental structure, resembles Africa. Its mountains, which are near the coast, slope abruptly to the surrounding waters.

61. **The principal mountain system** is composed of the Australian Alps, the Blue, and the Liverpool mountains. This system is in the eastern and southeastern part of the continent.

62. **The great plateau** of Australia is in the central part, traversed by low ranges of mountains. The slope of this plateau is toward the south.

63. **The lowland plains** are chiefly in the southern and southeastern part. The Gulf of Carpentaria is also surrounded by a large, well-drained plain.

64. **Several large lakes** are in the southern, and a large number of small ones, in the western part.

65. **Laws of Structure.**—A careful study of the Relief Maps on pages 140–144 show that the evolution of the Earth's features have been in accordance with definite laws.

66. These are somewhat complex, but they involve the following general principles :

Each continent has high borders and a low center. Its surface, therefore, is basin shaped.

The greatest length of each continent is in the direction of its principal mountain system.

The general shape of each continent is that of a triangle.

The highest mountains border the largest oceans.

The greatest elevations of land are in the Torrid zone.

67. It must also be kept in mind that the continents were not always where they are now, nor did they always have the shape they now have. Whatever changes in position, level, or outline may have taken place, the laws of structure have remained unaltered.

## WHAT HAS BEEN TAUGHT IN CHAPTER III.

*The Earth's surface comprises about 144,000,000 square miles of water and 53,000,000 of land. Of the latter 3,000,000 are islands.*

*The land surface consists of triangular shaped continents, extending from the north toward the south.*

*Three of the continents are, for the greater part, in the North Temperate zone, and three mostly in the Torrid zone.*

*The land masses lying on opposite sides of the Earth are known as the Eastern Continent and the Western Continent. Their divisions are also called continents.*

*The northern group of continents is bounded by very irregular coasts, and is noted for the great number of indentations.*

*The Eastern Continent extends from northeast to southwest, having a length of about 10,000 miles. Its main axis is the Himalaya mountain system.*

*The Western Continent consists of two triangles of land, extending from north to south about 11,000 miles. Its main axis is the Rocky mountain system.*

*Asia is the largest continent. Its highest point is Mt. Everest. From the great plateau of the Himalaya mountains,the surface slopes in every direction toward the surrounding oceans. The Dead and Caspian seas are below the ocean level.*

*Europe, in proportion to its size, has a larger coast line than any other continent. Its main axis is the Alpine system of mountains, from whose summit it slopes gently to the north and abruptly to the south.*

*Africa is an immense plateau rising abruptly out of the sea. Its main axis is on the eastern side. Its surface is drained chiefly by the Nile, Zambeze, and Congo or Livingstone rivers.*

*North America consists of a great plain bordered on the east and the west by mountain chains. Of these, the Rocky mountain system is the most extensive. It occupies the western part of the continent.*

*The great continental plain extends from the Arctic ocean to the Gulf of Mexico. Its drainage in the southern part is effected by the Mississippi river system.*

*The Appalachian mountain system comprises several parallel ranges lying near the eastern border.*

*South America resembles North America in its continental structure, consisting of a great plain bordered by parallel mountain ranges.*

*The Andes, a continuation of the Rocky mountains, forms the main axis.*

*The great continental lowlands extend from the north to south.*

*The Amazon, Orinoco, and La Plata rivers constitute the chief drainage systems.*

*Australia also resembles the American continents, consisting of a low plain bordered by mountains on the east and the west.*

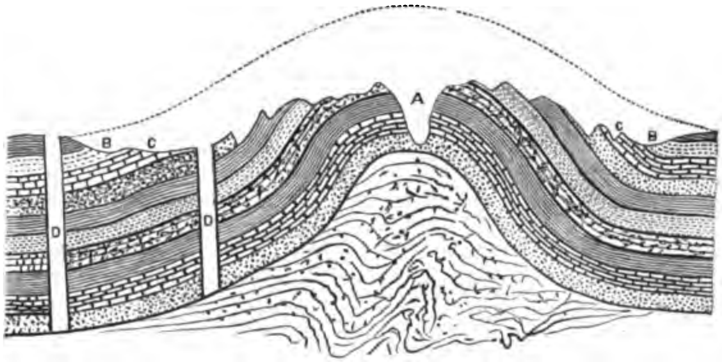
# CHAPTER IV.

## MOUNTAINS, PLATEAUS, AND PLAINS.

1. **Mountain Structure.**—It is now believed that mountains have been formed by a *shrinking* of the Earth's crust, owing to its gradual cooling.

2. **The shrinkage** being greatest in the interior, the overlying strata are crushed together sideways.

3. **Such side pressure,** it is evident, forms immense wrinkles hundreds of miles wide, and often many thousand miles long.[1]

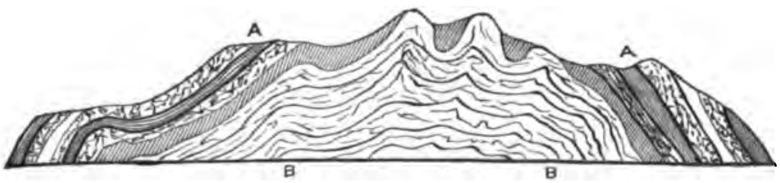



Section of Uintah Mts. *A*, Green River Cañon ; *BB* and *CC*, Strata worn by water ; *DD*, Mining Shafts. The dotted lines show the original fold.

4. **The simplest mountain range** is one consisting of a single fold or wrinkle. The Uintah range of Utah is an example of this kind of mountain formation.

5. Oftener, a range consists of **several gentle folds,** as in the case of the Jura mountains.

6. But most frequently, the strata, instead of occurring in gentle folds, are **pressed closely together.** This kind of mountain structure is finely illustrated by the Coast Range of California and the Appalachian system of the Atlantic coast.




Section of Coast Range near Santa Cruz, Cal. The folded strata at the surface have been worn away. *AA*, Strata ; *BB*, Granite Axis.

7. **Mountain Chains.**—Mountain chains are always composed of *sedimentary* or *stratified rock.*[2]

8. It is a remarkable fact also, that the strata which are found in a mountain chain are much thicker than the *same* strata occurring elsewhere.[3]

9. **Mode of Formation.**—Mountain systems, therefore, seem to be directly connected with thick accumulations of sediment.

10. **These great accumulations** always occur along the shores of continents, where everything washed from the surface of the land is finally deposited by the agency of rivers, winds, waves, and tides.

[1] There is evidence, also, that in many instances the crust of the Earth has been rent, and that either igneous or metamorphic rock has been forced upward through the fissure thus formed.

[2] In many instances igneous rock has been thrust upward to the surface.

[3] "The strata composing the Appalachian system are 40,000 feet thick, while the same strata on the Mississippi river are only 4,000 feet."—*Le Conte.*

The Bad Lands of Dakota.—Water-Sculptured Mountains.

11. We are thus led to believe that mountain chains are formed by the wrinkling or crumpling of the Earth's crust along those sea shores on which accumulations of sediment have been deposited.[1]

12. **That mountains have once been sea bottoms** is shown by the following facts:—

*First.* They are composed of aqueous (*ā'-que-us*) rocks.

*Second.* The fossils found within their strata represent chiefly those types of life that have inhabited the sea only.

*Third.* In several instances, strata of sea shells in their *natural* state, mixed with sea sand, are found in mountain ranges at an elevation of many feet above the sea.[2]

13. **Laws of Position.**—By closely studying the relief maps, the pupil will observe certain general laws concerning mountain structure.

*First.* The highest mountain peaks occur in the largest continents.

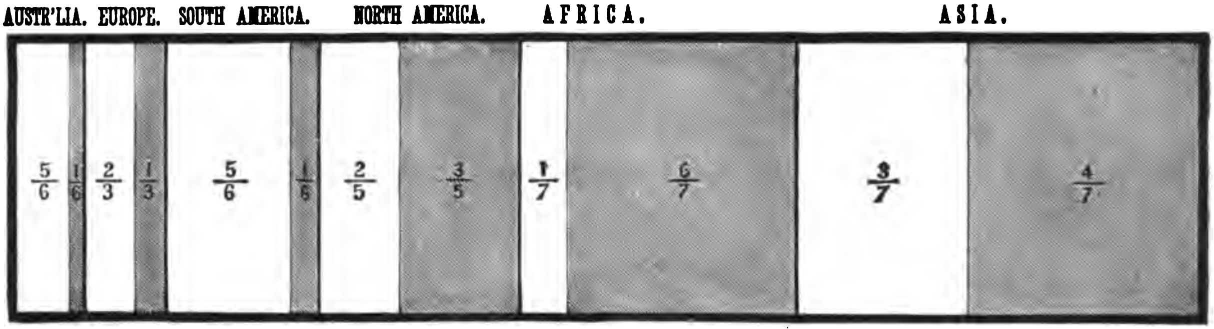
*Second.* The most extensive systems are found in the largest continents.

*Third.* The average height of mountains is least toward the poles and greatest toward the equator.

14. **Continental Axes.**—The chief systems of a continent may be considered its skeleton, inasmuch as they give to the continent its general shape and extent. They are, therefore, called the axes of the continent.

[1] "It is also certain that parallel ranges of a system have been formed successively, and also successively coastward."—*Dana.*

[2] Such deposits occur at San Pedro, California. The highest stratum is about four feet below the surface, and is overlaid by sandstone. Other strata are found, at irregular intervals, below the one mentioned.




The Relative Proportion of Highlands and Lowlands.—Highlands shaded, the Lowlands white.

15. **The Rocky and Appalachian** systems, embracing the Great Central Plain between their crests, form the general outline of North America.

16. **The Andean and Brazilian** systems constitute a frame upon which South America is modeled; having, like North America, mountain borders, between which lies the great continental plain.

17. **Europe and Asia** are each traversed from northeast to southwest, by irregular and complex systems. From the great, central backbone of each, numerous spurs project, forming the numerous peninsulas for which these continents are noted.

18. **Africa and Australia** resemble each other in their mountain systems, which form a rim surrounding a comparatively low interior.

19. **The importance of mountains** cannot be too greatly estimated. On their presence and position, the rainfall, drainage, and climate of a country almost entirely depend.

20. **The most extensive mountain system** in the world is the Rocky and Andean, which has a total length of nearly 11,000 miles, reaching from Alaska to Patagonia. In the western part of the United States, there are about 50 parallel ranges in this system.

21. **The highest mountain peak** in the world is Mt. Everest, situated in the Himalaya range. Mt. Everest is over 29,000 feet, or nearly 5½ miles high.

22. **Plateaus.**—The highlands of the Earth are not always mountains; often, they consist of vast upland plains, called plateaus. These are usually situated between those mountain ranges which form the margins of a mountain system.

23. Thus, the **Great Basin** lies between the Rocky and the Sierra Nevada mountains. The **plateau of Thibet** is situated between the Himalaya and the Kuen Lun range. The plateau of Bolivia lies between the two main ranges of the Andes.[1]

24. The surface of a plateau is not necessarily level; on the contrary, it is often rugged and mountainous. The Andes mountains rest on a high plateau. The Great Basin is covered with a network of mountains and valleys.

25. **About one-half of the Earth's land-surface** consists of plateaus and highlands. Generally, they are infertile and ill-adapted to habitation. They contain, however, nearly all the mineral wealth of the world. Their proportion is approximately shown in the diagram.

[1] Other plateaus, as the Mexican, rise from the sea level in terraces, or else by a gradual and gentle slope, like the "Plains" of North America. The Plains rise imperceptibly from the Mississippi river to the foot hills of the Rocky mountains, where their altitude is about 5,000 feet.

26. The principal plateaus of the Western Hemisphere are those of the Western Highlands and Mexico, in North America, and the plateaus of Bolivia and Titicaca, in South America.

27. The plateaus of the Eastern Hemisphere are noted for their great size and elevation.

28. **Africa** is an immense plateau, having an elevation varying from 2,500 to 8,000 feet.[1]

29. **Asia** contains the most notable plateaus of the world, both as regards size and elevation. The most prominent are the plateaus of Thibet, Gobi, Persia, and Arabia.

30. **The chief plateaus of Europe** are the Austrian plateau and the Spanish peninsula.

31. **Australia** is skirted on the eastern and the western border by low plateaus, having an average altitude of 2,000 feet.

The following table shows the most notable plateaus of the world :

| Names of Plateaus. | Area in Square Miles. | Average Elevation, in Feet. |
|---|---|---|
| **Africa (without lowlands)** | 9,500,000 | 8,000 to 6,000 |
| **Arabia** | 700,000 | 4,000 to 5,000 |
| **Gobi** | 400,000 | 4,500 to 5,500 |
| **Persia** | 800,000 | 8,000 to 4,000 |
| **Spanish Peninsula** | 225,000 | 2,500 to 4,000 |
| **Mexican** | 180,000 | 6,000 to 8,000 |
| **Thibet** | 160,000 | 11,000 to 12,500 |
| **Bolivia** | 120,000 | 10,000 to 13,000 |
| **Great Basin** | 120,000 | 4,500 to 6,000 |

32. **Plains.**—Plains and lowlands form the remaining half of the land-surface. They are large tracts, usually of level country, having an elevation of not more than 1,000 feet.

33. There are two great classes of plains, differing both in origin and general features.

34. **Alluvial Plains.**—Alluvial plains owe their origin to rivers whose waters carry material from the mountains and deposit it in places where the current runs less swiftly. This occurs chiefly at the mouths of rivers and along their lower courses. Alluvial plains are always level.

35. The plains of the Amazon, the Orinoco, the La Plata, and also those of China and Hindostan, are examples of this class. Much of the Mississippi valley has also been formed in a similar manner.

36. **Marine Plains.**—Marine plains are old sea bottoms which have been gradually lifted above the sea level.

37. The plains surrounding the Caspian and Baltic seas, the northern part of the Mississippi valley, and especially those which border large oceans, are examples of marine plains.

[1] Sahara, in the northern part of Africa, has an average altitude of 1,500 feet.

The Steppes or Plains of Siberia, looking south toward the Altai mountains.

38. **Marine plains,** especially those of recent formation, are often sandy and sterile. Their soils generally contain large quantities of salt, soda, and potash.[1]

39. **The Steppes of Russia and Siberia** are marine plains, but they have been, in many places, covered with sediment brought down by the rivers flowing through them.

As the altitude increases, the plain generally becomes hilly. Such is the case with the Siberian and the North American plains.

40. **The plains of North America** lie between its two mountain systems. In the higher portions, they are covered with forests of valuable timber; but toward the north, they become a dreary, frozen waste.

41. Much of the southern portion is a vast cypress swamp whose surface is scarcely above the sea level.[2]

42. The central and southern portions of the plains of North America supply nearly one-third of the wheat and corn, and about one-half of the cotton, used in the civilized world. The level plains of North America east of the Mississippi are called *prairies;* those west of the Mississippi, "*the plains.*"

43. **The plains of South America** also lie between the continental mountain systems. Those of the Orinoco are alluvial. They are called *llaños* (*lyah'-noce*). For a few months, they dry and parch under the scorching rays of a tropical sun, until they resemble a desert.

44. Then, the rainy season sets in; the streams overflow their banks; and, save here and there a projecting knoll, the whole country, as far as the eye can reach, is under water.[3]

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[1] The plain which constitutes the southwestern part of California is a remarkable example of recent, marine plain. Layers of sea shells in a perfect state of preservation are frequently found at a distance of but a few feet from the surface. The unpetrified skeletons of whales are found in large numbers, some at an altitude of several hundred feet above the sea level.

[2] These cypress swamps are called everglades. The great Dismal Swamp of Virginia is a notable example.

[3] Just before the wet season begins, the herds of cattle and horses stampede; and in due time, reach the foothills of the plateaus. The few that lag behind, usually perish. It is not an uncommon sight to see a small hillock which projects above the surface of the water, crowded with wild animals of every species, struggling with one another to keep a foothold above the water. Alligators and other reptiles that have remained dormant during the drought, appear in great numbers.

45. **The plains of the Amazon** are covered with forests, so dense and impenetrable, that the streams of water flowing through them are often the only highways. These plains are called *selvas*. From them are obtained a great variety of ornamental and dye woods. The India rubber tree (*Siphonia elastica*) is abundant.[1]

46. **The plains of the La Plata,** called *pampas*, have an extent of about 175,000 square miles. They are well drained, and afford pasturage to immense herds of cattle, which outnumber those in all other parts of the world together. Millions are slaughtered annually for their hides, horns, and beef. Neither the rainy nor the dry season is severe. Hence, the pampas are the most valuable part of the continent, in respect to their natural resources.

47. **The three plains of South America** are not separated by any distinct, physical features.

48. **The northern parts of Europe** and Asia constitute an immense plain bordering the Arctic ocean. The three divisions of this plain comprise the forests of the south, the agricultural lands of the middle, and the tundras of the northern part.

49. The Ural mountains, crossing this plain at right angles to its line of greatest length, form a ridge corresponding to the Height of Land of the American plains.

50. **The higher portions** of this plain are the *steppes* (*steps*). That part bordering the Arctic ocean is generally known as the *tundras* (*toon-drahs*).

51. **In summer, the tundras** are swamps in which nothing but the lowest forms of vegetable life, such as mosses and lichens, can exist. In winter, they are frozen wastes.[2]

52. **Africa** contains no extensive plains. There are lowlands bordering the ocean, a number of alluvial plains along the larger rivers, and parts of the Sahara; but there are no such plains as characterize the other continents.

53. Of the river valleys, that of the Nile is the most important. This valley, owing to the annual overflow of the Nile, is exceedingly fertile, and produces valuable crops of grain.[3] Each flood deposits a fresh layer of soil on the surface of the valley. Were it not for this overflow, the valley of the Nile would be sterile and uninhabitable.

54. **The oases** of the Great Desert are remarkable for their perpetual fertility. They are well supplied with water all the year, and in consequence, present a strong contrast to the surrounding desert.

55. In structure, the oases are depressions in the limestone formation. A stratum of clay and sand forms the bottom of the basin, holding the water that finds its way from the surrounding highlands.[4]

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[1] The only inhabitants, except the traders who live along the navigable rivers, are savages of the lowest type of humanity.

[2] The cause of these conditions is remarkable and interesting. The mouths of the rivers flowing into the Arctic ocean are in high latitude, and hence are frozen during a great part of the year. The rivers having no open channel, overflow their banks and convert the whole country into a vast morass. It was in the tundras of the Lena river that Lieut. De Long and his party, of the ill-fated Jeannette, perished.

In their general features, the Arctic plains of the Eastern Hemisphere do not differ from the North American plains in the same latitude.

[3] The rising of the river begins in June and continues until the middle of September, when it begins to subside. The water, at the highest stage, is sometimes 30 feet above low water level.

[4] There are about 30 oases, of which 20 are inhabited. The largest, Ammonium, contains several towns, and has an area of 3,000 to 4,000 square miles. The oases are stopping-places for caravans, where they obtain supplies of food and water.

56. **The lowlands of Australia** are the alluvial valleys of the Murray river and its tributaries. These valleys are extremely fertile and are productive of great wealth.

57. The great plains of Australia, however, lie in the interior of the continent. During the rainy season, they are more or less productive, but in the summer they soon become parched and desolate.

58. There are also large, sandy plains containing salt lakes, but destitute of all vegetation, save a long, stiff grass, called spinifex. Swampy lands are occasionally found in these plains. Owing to the great heat and the lack of water, the central Australian plains are uninhabitable.[1]

## WHAT HAS BEEN TAUGHT IN CHAPTER IV.

***That mountains have been formed by the crust of the Earth shrinking upon a contracting interior, thus producing immense folds, or wrinkles.***

***The wrinkles or mountains thus formed are made by side crushing, and frequently igneous rock is thrust upward through rents found in the broken strata.***

***Sometimes the mountain chain consists of a single fold or plication, but oftener, of several folds crushed together.***

***Mountain chains are composed of enormous thicknesses of sedimentary rock.***

***The mountain systems of a continent form the skeleton, which gives the continent its outline.***

***The ranges composing a mountain system are generally parallel to one another.***

***The chief mountain systems of the Western Hemisphere extend nearly north and south.***

***Those of the Eastern Hemisphere extend from the northeast to the southwest.***

***Plateaus are elevated surfaces which usually extend between parallel mountain ranges.***

***The chief plateaus of the Western Hemisphere are the Western Highlands and Mexican plateau of North America, and the Bolivian and Andean plateaus of South America.***

***Those of the Eastern Hemisphere are Arabia, Gobi, Persia, and Thibet; the latter being the highest plateau in the world.***

***Their surfaces are not always level, being frequently rugged, and often studded with mountain peaks and short mountain ranges.***

***Plains are formed either by the deposition of sediment along the course of a river, or by the elevation of sea bottoms.***

***Many marine plains have been subsequently shaped by rivers. Recent marine plains have usually a sandy soil and are frequently sterile.***

***The chief plain of North America extends from the Arctic ocean on the north to the Gulf of Mexico on the south.***

***The principal plain of South America extends from the mouth of the Orinoco to the mouth of La Plata river, being drained by the Amazon, Orinoco, and La Plata rivers.***

***The largest plains of Europe and Asia border the Arctic ocean, and rise from the sea in successive terraces.***

***The plains of southern Asia are chiefly alluvial, and constitute the most thickly inhabited part of the continent.***

***The oases of the Great Desert, the most remarkable of African plains, are depressions surrounded by limestone formation, and underlaid with a stratum of clay.***

***The plains of Australia are in the interior of the continent. They are generally destitute of vegetation and are subject to excessive drought.***

[1] The average daily temperature frequently exceeds 110° F. Howlitt, an explorer, states that he has recorded a temperature of 139° F.

# CHAPTER V.

## ISLANDS.

1. **Area and Classification.**—About 3,000,000 square miles, or nearly one-seventeenth of the land surface of the Earth, consists of islands.

2. These, with respect to their structure and position, are either continental or oceanic.

3. **Continental Islands.**—Continental islands are generally elongated in shape, and are parallel to the coasts near which they lie. In structure, they are usually like the neighboring continents.

4. Comparing their strata with those of the adjacent continent, we find not only similar species of living plants and animals, but also the same kind of fossils.

5. From this evidence, continental islands are believed to be *partly submerged mountain chains*, belonging to the continent to which they are adjacent.

6. On any map of the Western Hemisphere, trace a continuous line from Yucatan, through the West Indies and the Lesser Antilles (*ahn-teel'*), to the mouth of the Orinoco river. This chain of islands is a spur of the Rocky mountain system.

7. On a map of the Eastern Hemisphere, also trace a line from Kamtschatka, through the Kurile islands, the Japan Empire, the Liukiu and Philippine (*fil'ip-pin*) islands. This is a mountain range, lying parallel to the eastern shores of Asia.

8. Sumatra, Java, and the chain lying to the eastward, form a mountain range parallel to the one which constitutes the peninsula of Malacca.

9. This range may be traced northward to the divide between the Irrawaddy and the Ganges river.

10. From the western extremity of the Aliaskan peninsula, a chain of islands extends nearly to Asia. This chain belongs to the Rocky mountain system.

11. The chains of islands just described are both mountainous and volcanic. In fact, they contain nineteen-twentieths of the volcanoes in the world. In more than one instance, every island of the chain is a volcanic cone.

12. **There is one group** of continental islands which is neither mountainous nor volcanic. It comprises the islands of the Arctic archipelago.[1]

13. These islands form a *partly submerged marine plain*, which seems to be a continuation of the Arctic plain of North America. Although not mountainous, their surface is rugged, and, in many instances, "reefs of rock rising abruptly out of the sea, form their natural boundaries."

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[1] Greenland, Cumberland, and Banks islands, together with the archipelago lying northeast of North America, constitute the exception mentioned. Comparatively little is known about this group of islands. Baron Nordenskjöld, who penetrated Greenland to a distance of 100 miles, found the interior a barren plateau, covered with ice and snow. According to his opinion, Greenland consists of a number of islands joined by a perpetual bond of ice.

14. **Oceanic Islands.**—Nearly all of the oceanic islands are in the Pacific ocean, at a considerable distance from any continent. These groups constitute the divisions of Polynesia and Micronesia.

15. Oceanic islands differ from continental islands in structure; for while the former are similar to the main land near by, the latter are formed either of volcanic ejections, or of limestone.

16. The islands formed of volcanic ejections are usually active volcanoes having a considerable altitude; those composed of limestone are the low tops of coral (*kŏr'ăl*) reefs, and are called *coral islands.*

Coral Reef and Lagoon.

17. **Coral Islands.**—Coral islands are, in many respects, the most interesting features in the world. Each island is an irregular ring of land, usually broken in several places, and having a surface only a few feet above the sea level.

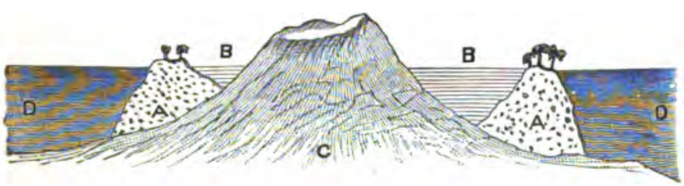
18. The island forming this ring is called an atoll (*a-tŏl'*); the lake inclosed by the atoll, a lagoon (*lă-goon'*).

19. **Within the lagoon** the water is shallow, never exceeding forty or fifty fathoms in depth. Outside the lagoon it is unfathomable at a short distance from the shore.

20. **The atoll** is nearly always covered with a luxuriant growth of vegetation, limited however, to a very few species.[1]

21. **Structure.**—In many instances, a volcanic mountain occupies the center of the lagoon. This fact is an important one, because it tells the wonderful story of the building of the island.

22. **The reefs** composing the island are limestone, and the limestone has been taken by the coral polyp, atom by atom, out of the water to make its skeleton.



*A A*, Section of reef; *B B*, Lagoon; *C*, Volcanic Mountain, *D D*, Ocean Waters.
Section of a Coral Island.

23. **The Coral Polyp.**—The coral polyp is a *zoöphyte*, a form of animal life which may be likened to a tree, with its trunk and multitude of branches. The mouths of the coral polyp completely cover its upper surface, closely resembling the petals of flowers, which they rival, both in color and beauty.

24. In a single community the growth of the coral is chiefly upward; but when multitudes of such communities live side by side, their branches interlock, and finally form one compact mass.

[1] There are seldom more than forty or fifty species,—often not more than half that number. These consist of the cocoa and date palms, the bread-fruit tree, the banana, and a number of less important kinds.

Vegetation of a Coral Island in Polynesia.

25. Thus, in time, the fringe of coral becomes a solid ring-like wall, completely encircling the island on whose shores the seemingly insignificant animal-flower was cast.

26. Coral polyps sometimes multiply by eggs, or egg-germs, and these are distributed along the shore by winds and waves. They multiply *chiefly*, however, by the process of budding and branching just described.

27. Although the coral polyps cannot live more than 120 feet below the surface of the water, yet the reefs they have built extend thousands of feet in depth. How, then, did the polyp reach these depths? We shall see.

28. **Formation of the Island.**—The researches of Darwin have led to the discovery that the islands and volcanic cones, along whose shores the coral polyps built, have been gradually sinking.

29. As, little by little, these islands sunk, the coral built upwards, always keeping near to the surface of the water, but never building above it. In time, the waves lashing the crests of the reefs, broke off masses and piled them up, just as now the storm waves sometimes throw up bars of sand and gravel on our coasts.

30. Waves and migrating birds scattered over the island the seeds brought from other lands. In the course of years, these covered the island with a mantle of verdure.

31. Sometimes, the volcanic mountain reaches a great elevation; often, its summit is scarcely above the water level, while in other instances, it is entirely below the surface, and covered with coral growths.

32. Apparently the Polynesian and Micronesian groups of islands consist of an immense plateau about 6,000 miles long and 2,000 miles wide, almost wholly submerged.

33. Examine a map of Oceanica and you will not fail to notice that the islands composing each group are in regular lines, just such lines as would appear above the surface of the ocean, if the plateau of Thibet, for instance, were submerged till only the highest crests were out of water.

34. **Fringing Reefs.**—Another kind of coral architecture, namely, the reefs which often skirt the shores of continents, possesses more than ordinary interest. They seldom exceed half a dozen miles in width, while they are sometimes many hundred miles long.

35. **The West Indies** and the Bermuda islands are fringed with these reefs. The peninsula of Florida owes its shape chiefly to them. On the northeastern shores of Australia, the coral reef exceeds 1,250 miles in length.[1]

36. **Wave-formed Islands.**—The rivers of the Atlantic slope of the United States are constantly depositing their sediment all along its eastern shores. But while the river currents tend to carry it seaward, the waves and wind push it landward.

37. Consequently, between the two opposing forces, a long reef or sand-spit is thrown up along the shore and parallel to it. The sand-spits opposite Hatteras inlet are fine examples of wave-formed islands.

## WHAT HAS BEEN TAUGHT IN CHAPTER V.

***Islands, constituting about one-seventeenth of the land surface of the Earth, have an aggregate area of 3,000,000 square miles.***

***Continental islands always lie near and parallel to the continents of which, in structure, they form a part.***

***Neither the rocks that compose continental islands, nor the forms of life upon them, differ from those of the continents near which they lie.***

***They constitute partly submerged mountain chains and plateaus.***

***Nearly all continental islands are volcanic, and they contain nineteen-twentieths of the volcanoes of the globe.***

***Oceanic islands are always at a great distance from any large body of land, nearly all of them being in the Pacific ocean.***

***The various islands composing the groups are usually ranged in parallel lines.***

***Oceanic islands consist either of volcanic cones, or else reefs of coral limestone.***

***The coral island is usually a ring-shaped reef inclosing a shallow lagoon, in the center of which there is a volcanic mountain.***

***Each atoll is the work of the coral polyp, which, building in shallow water, surrounded the island with a reef of coral limestone.***

***While the island slowly sank, the coral polyp built as rapidly towards the surface.***

***Many continental shores are fringed with coral reefs, formed in much the same manner as the coral islands.***

***The vegetation of coral islands is limited to a few species of palms.***

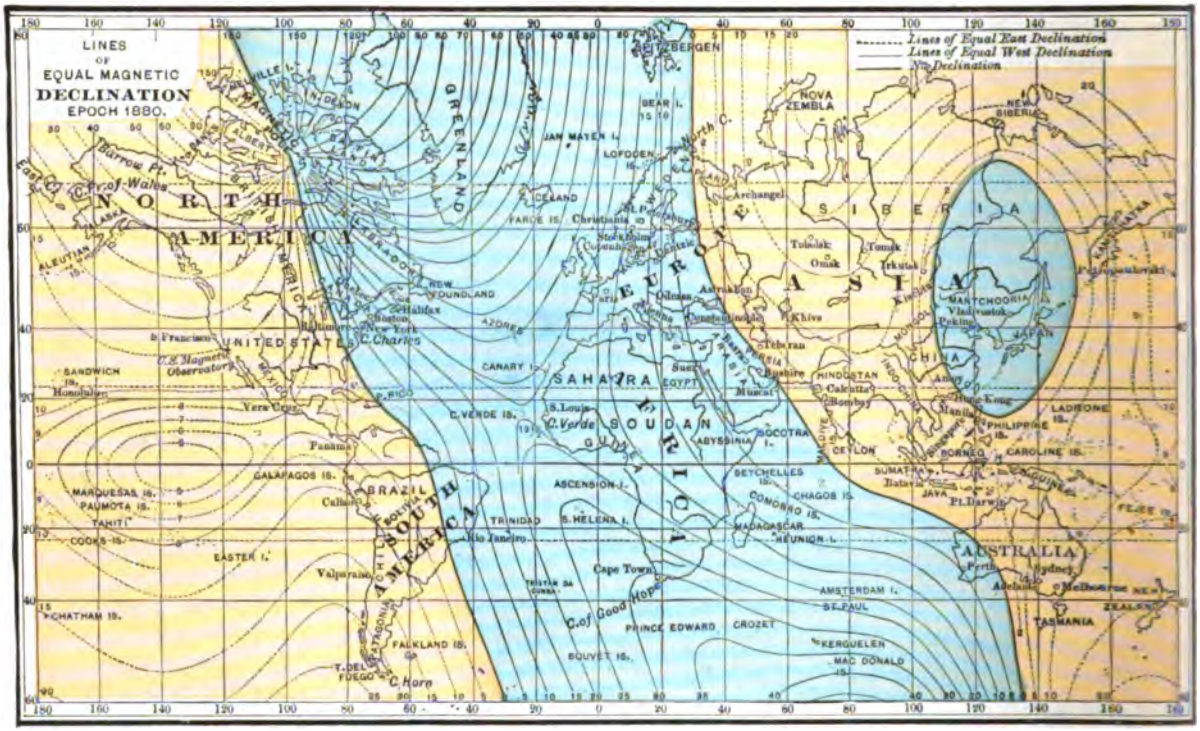
[1] "In the tropical Pacific every *high* island or previously existing land is surrounded by a reef which attaches itself to the shore line and extends outward on every side just beneath the water level, as far as the condition of depth will allow, forming a submarine platform bordering the island or other land."

"In many cases, besides the fringing reef there is another reef surrounding the island like a submarine rampart, at the distance of from ten to fifty miles. As the reef rises nearly to the surface of the sea, its position is indicated by a snowy girdle of breakers surrounding the island, and the snowy girdle is gemmed with wave formed green islands. Within this girdle, and between the rampart and the island, there is a ship canal twenty or thirty fathoms deep. Through breaks in the coral rampart, ships enter this channel, and find secure harbor in a stormy sea."—*Le Conte.*

Circular reefs or atolls have already been described. *Every circular reef marks the locality of a sunken island.*

# CHAPTER VI.

## MAGNETISM.




1. **Properties.**—A magnet is usually a bar of steel which has the property of drawing towards itself pieces of iron or nickel. When balanced and suspended by a string, the magnet comes to rest, pointing in an unvarying direction.

2. The word magnet is derived from *Magnesia,* a city of Asia Minor, near which lodestone, a kind of iron ore having magnetic properties, was originally found.

3. An artificial magnet is usually a piece of steel which has been magnetized by electricity, or by rubbing its ends with another magnet. Steel or nickel must be used, because these metals retain their magnetism permanently, while soft iron does not.

4. If iron filings are sprinkled on a piece of paper under which a bar magnet lies, they will cluster in curved lines about the ends of the bar, while few or none of the filings adhere to the center, showing that magnetism appears to be strongest at the ends of the bar.

5. **Polarity.**—The two ends of the bar, at which the magnetism is strongest, are the poles of the magnet. For convenience, they are called the *north-seeking* or —, and the *south-seeking* or + poles.

6. **The like poles** of two magnets repel, the **unlike** poles attract each other. Either pole attracts bits of unmagnetized iron and nickel.

7. If a small piece of steel, as half a knitting-needle, be suspended by a strand of silk and exactly balanced, it will rest indifferently in any position to which it may be pointed.

8. But if the ends of the needle be rubbed, one by the marked, the other by the unmarked end of a magnet, the needle no longer remains indifferent to its position : it turns until it points nearly or quite **north and south.**

9. No matter how carefully you may change its position, the needle will swing back until it regains its fixed direction.

10. It does not even remain in **balance,** for, as soon as the needle is magnetized, the north-seeking end (north of the equator) turns downward or "**dips.**"

Iron filings strewn upon a sheet of paper held over a Magnet.

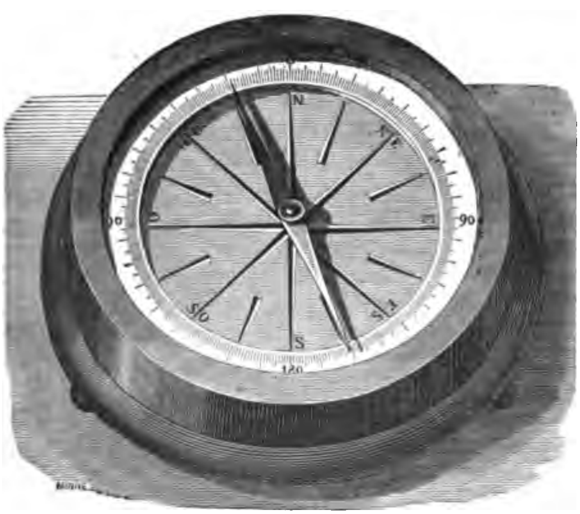
11. **The Compass.**—A compass consists of a small magnet, called a needle, so poised on a pivot that it turns freely. In the mariner's compass the needle is fastened to a circular card, on whose circumference the names of the cardinal points and their subdivisions are printed. Both needle and card turn on the pivot.[1]

12. No matter in what part of the world the compass may be—on sea or on land—the needle always seeks its north-and-south position.

13. This wonderful property of the compass-needle makes it of priceless value to the sailor ; as without it, the navigation of the ocean would almost be an impossibility.

14. **Magnetic Variation.**—But the compass-needle does not always point exactly north and south. In fact, there are but very few places on the Earth where it does, and these places are constantly changing.

15. Look on the map at the beginning of this chapter and find the line marked 0°. In 1880, everywhere along this line the compass-needle pointed due north and south. This line is called the **line of no declination.**



The Compass.

16. In all places **east** of this line, the north-seeking end of the needle turns a little towards the west; in all places **west** of the line it is deflected eastward. The figures at the end of each line tell how many degrees, east or west, the direction of the needle varies from the true meridian.

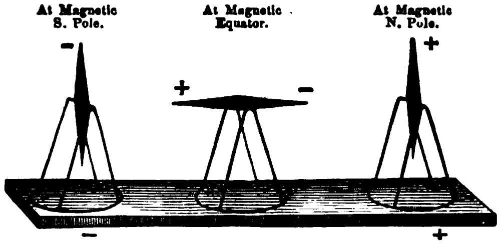
17. **Magnetic Poles.**—These lines approach towards the north, and finally intersect in the western part of Boothia Land. The point of intersection is the *magnetic North Pole.*[2]

18. **Magnetic Dip.**—At the magnetic North Pole, a needle suspended as you see in the

[1] The compass box is so mounted that it always remains level. The box is sometimes filled with a liquid on which the card and needle *almost float,*—only a very slight weight resting on the pivot.

[2] The latitude of the magnetic North Pole is 70° 8′ N.; its longitude is 96° 45′ W. This position has been determined by actual observation. The exact locality of the magnetic South Pole is only theoretically known.

cut, has a vertical position, the *north-seeking* or – *end being down.* Going southward, however, it gradually recovers its position, until, at a point near the equator it ceases to dip and its position is *horizontal.*



Position of the needle at different parts of the Earth.

19. Going still farther southward, the south-seeking or + pole now dips. The dip constantly increases till the south magnetic pole is reached, where the needle's position is again vertical; this time the *south-seeking pole is downward.*[1]

20. **The Earth's Directive Force.**—Thus we see that the Earth itself has all the properties of a magnet. Like a magnet it has two magnetic poles, and these affect the compass-needle in just the same manner as does any other magnet.

21. **Change in Variation.**—We must keep in mind that not only is the compass variation constantly changing, but also that the *rate of change* is seldom alike in any two places distant from each other, and is itself constantly changing. In fact, there are no factors or values pertaining to magnetism that are not subject to frequent and unexpected changes.[2]

22. **Periodic Variations.**—There is another series of magnetic variations having great interest, because they are governed by forces beyond the influence of the Earth. These are the daily, the monthly, the yearly variations, and the period of magnetic storms.

23. **The first three** of these, though very slight, are regular in occurrence, and tolerably uniform. It is thought that they are due to the influence of the sun and the moon. They are *vibrations* of the needle rather than permanent variations.

24. **Magnetic Storms.**—About every eleven years the magnetic needle is subject to violent disturbances which are closely connected with sun-spots. These disturbances are called "magnetic storms."

25. Whenever a sun-spot shows signs of agitation or rapid change, a powerful effect upon the magnetic needle is noticeable. Quiet sun-spots, on the contrary, have little or no effect.

26. **During a magnetic storm,** the needle trembles constantly and swings on its pivot over an arc measuring sometimes one or two degrees. The Aurora Borealis is often visible at the time of a severe storm, and telegraph lines frequently refuse to work.

27. Thus we see that the **magnetic needle never rests,** but forever swings back and forth, controlled by a force we know not. Fortunately for those who use the compass, these changes are always slight—sometimes almost imperceptible—yet they nevertheless exist.

[1] Ship compasses are so constructed that the needle and card are always horizontal. In the Arctic regions, the vertical force is so strong, and the horizontal force so weak, that the compass-needle will scarcely turn on the pivot. On whaling vessels, the helmsman frequently attaches a cord to the compass-box, giving the latter an occasional shake, in order that the needle may settle in some definite direction.

[2] The following table shows the changes in variation at Paris during the last 300 years:

| | | | |
|---|---|---|---|
| Variation in 1580, 11° 20′ E. | Variation in 1700, 8° 10′ W. | Variation in 1816, 22° 25′ W. | Variation in 1829, 22° 12′ W. |
| " 1618, 8° 0′ E. | " 1780, 19° 55′ W. | " 1823, 22° 23′ W. | " 1835, 22° 4′ W. |
| " 1663, 0° 0′ | " 1814, 22° 34′ W. | " 1828, 22° 5′ W. | " 1854, 22° 10′ W. |

In some parts of the United States, the annual change is 7¼′ (angular measure). In New Mexico and Arizona, there has been no change for several years. The yearly increase is greater toward the northern part of the continent. On the Pacific coast, the easterly variation is increasing; on the Atlantic coast and the Mississippi valley, the westerly variation is increasing.—*U. S. Coast Survey—Report for* 1883.

It is evident that the map used to illustrate this chapter will be useless ten years hence.

28. **What magnetism** is and why it so mysteriously controls the piece of steel in which it resides, are questions that cannot be answered. We know a few of the phenomena only, and there our knowledge ceases.

29. It is thought by many of the best observers and students of magnetism, that the magnetic poles are moving in irregular paths about the geographical poles. This theory is not yet fully confirmed.

30. In several countries, magnetic observatories have been established, under the control of their respective governments, for the purpose of investigating the phenomena, and studying the laws of magnetism.[1]

## WHAT HAS BEEN TAUGHT IN CHAPTER VI.

***Magnets are pieces of steel or nickel having the property of attracting other pieces of steel and nickel or bits of soft iron.***

***Steel and nickel retain their magnetism permanently, while iron does not.***

***A piece of steel accurately balanced, and then magnetized, rests always in a north-and-south position.***

***It no longer remains balanced, one end of the needle dipping toward the Earth.***

***The end of the needle pointing towards the north is called the north or − pole; the other, the south or + pole.***

***A mariner's compass consists of a magnet balanced and fastened to a card, on which the cardinal points are printed.***

***The compass-needle never points exactly north and south except on a certain irregular line called the magnetic meridian, or line of no declination.***

***West of this line, the − end of the needle points east of north. East of it, the − end of the needle points west of north.***

***At the magnetic North Pole, the needle takes a vertical position, the − end down.***

***At the magnetic South Pole, the needle is also vertical, the + end down.***

***Midway between the magnetic poles, the needle lies horizontal.***

***These variations are themselves constantly changing.***

***The rate of change is not uniform.***

***In every place, the magnetic needle has three*** **regular** ***variations—the daily, the monthly, and the yearly.***

***About every eleven years, there occurs a period, during which the magnetic needle is subject to unusual disturbances.***

***During this period of magnetic storms, the Aurora Borealis is of frequent occurrence.***

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[1] The United States Magnetic Observatory is located at Los Angeles, California. It is a low frame building, partly underground. The walls, each a foot in thickness, are double, and have a space of three feet between them. In the erection of this building no iron has been used—copper being employed for all metal work.

In the magnet room are three magnets, on which observations are taken. The first of these, suspended by a strand of unspun silk, is called the *unifilar magnetometer*. This instrument records variations in declination only. The second, or bifilar magnetometer, is suspended by two strands in such a manner that it is forced to point *east* and *west*. It is employed to measure the *strength* of the magnetic force. When this force increases, the magnet turns toward the geographical meridian. The third magnet, called the vertical force or balance magnetometer, is balanced on a knife edge, and is used to detect any change of dip or vertical force. All of these instruments rest on solid piers of masonry and each is covered by a glass globe, in order to guard it from possible disturbance.

To each magnet, a mirror is attached, before which a lamp is placed in such a manner that the mirror reflects a small dot of light upon a cylinder covered with photographic paper. Now, if the magnet turns ever so little, the dot of light moves, and its motion is recorded on the photographic paper. Each cylinder revolves once in twenty-four hours, and therefore the swerving ray of light has photographed an irregular line the whole length of the paper. The amount of deviation of this irregular line shows the variation for every minute of the day. Each magnet is provided with a telescope and scale, in order that readings may be made independently of the photographic record.

# CHAPTER VII.

## VOLCANOES AND VOLCANIC FORCES.

Crater of a Volcano.

1. **Definition.**—Volcanoes are openings in the Earth's crust, out of which steam, various gases, and molten rock or lava are forced.[1]

2. **Structure.**—The matter ejected collects about the volcanic opening, and builds up a cone-shaped mountain. At the top of the mountain, is a basin or depression, called the crater.

3. **Volcanic craters** vary in size, from a few rods to more than a mile in diameter. They are seldom more than four or five hundred feet in depth, measuring from the rim of the crater to its floor.[2]

4. **The floor of the crater** is the upper surface of a solid plug of lava which extends below to an unknown depth. This plug is generally blown out in fragments whenever an eruption occurs.

5. **At the surface** of the crater floor, are sometimes one or more small cones—really miniature volcanoes—which are nearly always emitting gases or small quantities of lava.

6. **With each succeeding eruption,** not only are the form and size of the crater changed, but, owing to the lava, scoriæ, and ashes falling upon its sides, the whole mountain is also greatly altered in outline and appearance.

7. **The scoriæ** of volcanoes consist of partly fused and blistered cinders, in appearance something like the clinkers that form in the grates of stoves burning soft coal. Volcanic "ashes" are not ashes, but matter which has been finely divided or pulverized by the eruption.

8. **Cause of Eruption.**—The origin of the forces which cause volcanic eruptions is not known with certainty; it is usually attributed to the formation of steam from the water which finds a passage into the hot reservoirs.

9. **The force** required to raise a column of lava to the top of Cotopaxi exceeds 25,000 lbs. per square inch. But volcanic forces have hurled rocks and steam from the crater of Vesuvius to a height of four miles. This force would hardly be greater were the volcanic opening and reservoir beneath filled with gunpowder and exploded.

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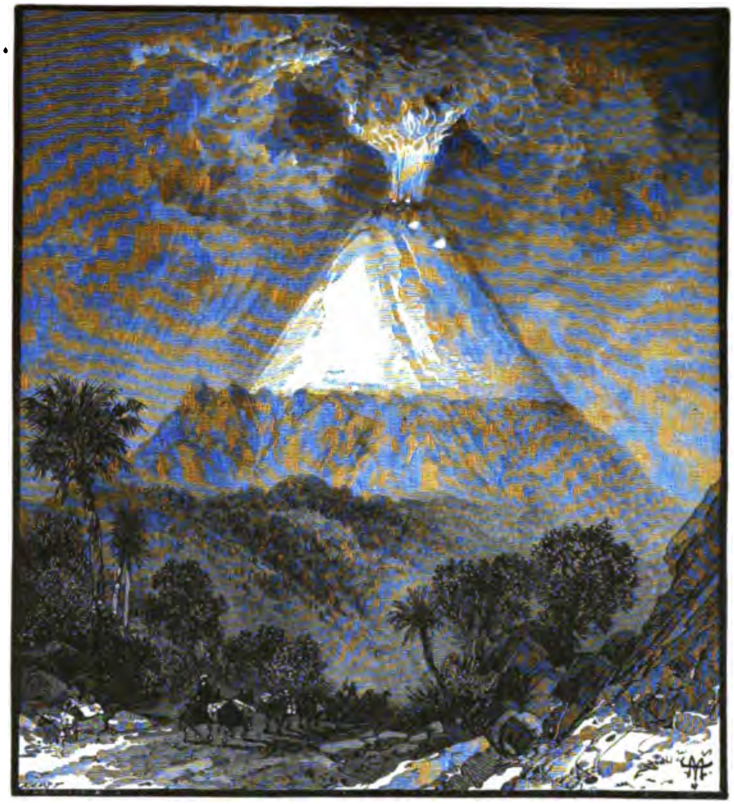
[1] The subterranean reservoirs in which the volcanic matter collects, and from which it is ejected, are not situated at a great depth below the surface of the Earth. Such reservoirs, while they indicate internal heat, have no reference to the "fluid interior" of the Earth.

[2] The diameter of the crater of Vesuvius has varied from 1,000 to 4,000 feet. That of Kilauea, the chief volcano of the Sandwich islands, is at present about three miles long and one mile wide. Several craters of lunar volcanoes exceed 50 miles in width.

10. With such enormous forces acting within, the crust of the Earth **yields at the weakest place.** But the weakest places are in mountain ranges, where the crust has been already rent or broken. Hence we find all of the volcanoes of the Earth scattered along the main axes of mountain systems.



Cotopaxi, the highest Volcano of South America. Eruption of 1855.

11. **Lines of Fissure.**—Not infrequently, there occur chains of volcanic mountains, all perhaps active, only a few miles distant from one another. In such cases, it seems probable that the volcanoes are all situated on the same rent or fissure.[1]

12. In at least one instance, the **volcanoes** composing a chain are **connected by subterranean channels.** Thus while Vesuvius has been active, Epomeo (*ā-pō'-mā-ō*), in the island of Ischia (*is'-kē-a*), a few miles distant, remains quiet.

13. But when the eruptions of **Vesuvius cease, Epomeo** at once **bursts forth** with terrible energy. During the past 2,000 years, volcanic activity has passed back and forth across the Phlegrean (*fle'-gre-an*) Fields, between Vesuvius and Ischia.

14. **The Phlegrean Fields,** situated on the north side of the bay of Naples, contain about twenty-five well defined craters. Two of these, Lake Avernus and the Lucrine lake—probably owing to subsidence—are filled with water.

15. **Types of Eruption.**—A few volcanoes are constantly active. Some, though discharging but little lava, are always emitting great quantities of steam and other vapors. Others again, remain quiet for centuries, and then burst forth with frightful energy.

16. **Stromboli** (*strom'-bo-lē*), on one of the Lipari (*lĭp'-ar-e*) islands, is an example of the former. It is constantly ejecting steam and lava, but with so little violence that one may safely approach within a few rods of the crater. Of the latter class, **Etna and Vesuvius** are notable examples.

17. **Phenomena of Eruption.**—When an eruption of a volcano of the latter type occurs, the floor of the crater is first blown into the air in fragments. At the same time, immense quantities of **steam** and **gas** are ejected, which, falling as a corrosive rain, cause greater destruction even, than the flood of lava which follows.

[1] On the island of Sumatra, less than 1,000 miles long, there are more than 100 active volcanic craters. In the Aleutian islands, there are 81 active volcanoes on a line less than 500 miles in length. In Iceland, there are 18; in the Azores, 6; and on the peninsula of Kamtschatka, 12 volcanic mountains, all showing signs of activity.

Successive Eruptions along the Line of Fissure.

18. **The flow of lava begins** after the discharge of steam, being at first violent, but afterwards steady and quiet. When the reservoir of lava has been exhausted, the eruption gradually dies away with the escape of gas.[1]

19. **Succeeding eruptions** may form new craters along the "line of fissure." Indeed, it is seldom that this does not occur during violent eruptions. The accompanying figure shows the manner in which these new craters are formed.

20. During the eruption of Vesuvius, A.D. 79, a new crater opening on the side soon built up a mountain exceeding Vesuvius in height. One rampart of the old crater has been named Monte Summa; the new cone is called Vesuvius.

21. **In volcanoes constantly active** like Stromboli, the eruptions, occurring at intervals of from ten to twenty minutes, consist merely of a puff of steam and other gases forcing their way upward through the lava.

22. **The seething lava** may be seen in the crater, rising toward the top. At last, a gigantic bubble forms, and bursting, hurls a shower of molten lava into the air.

23. The study of those volcanoes in and about the Mediterranean sea has contributed the most reliable knowledge concerning the phenomena of volcanic outbursts.

24. **Laws of Eruption.**—Situated in the most populous and enlightened centers, they have been studied for more than 2,000 years, and from their records the following conclusions are drawn :—

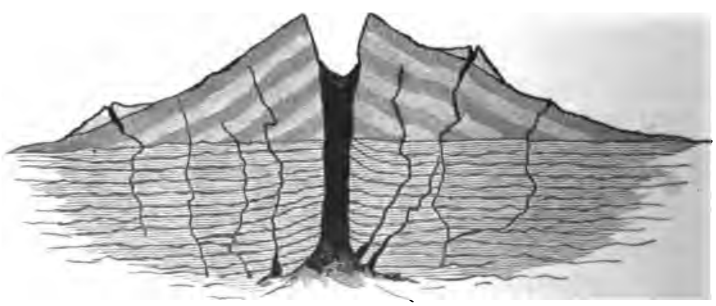
An eruption following a long period of inactivity is apt to be violent, or else long continued.

Feeble and short eruptions occur at much shorter intervals of time.

Volcanoes constantly active show very feeble energy.

Eruptions are caused by the accumulations of steam and gases under great pressure.

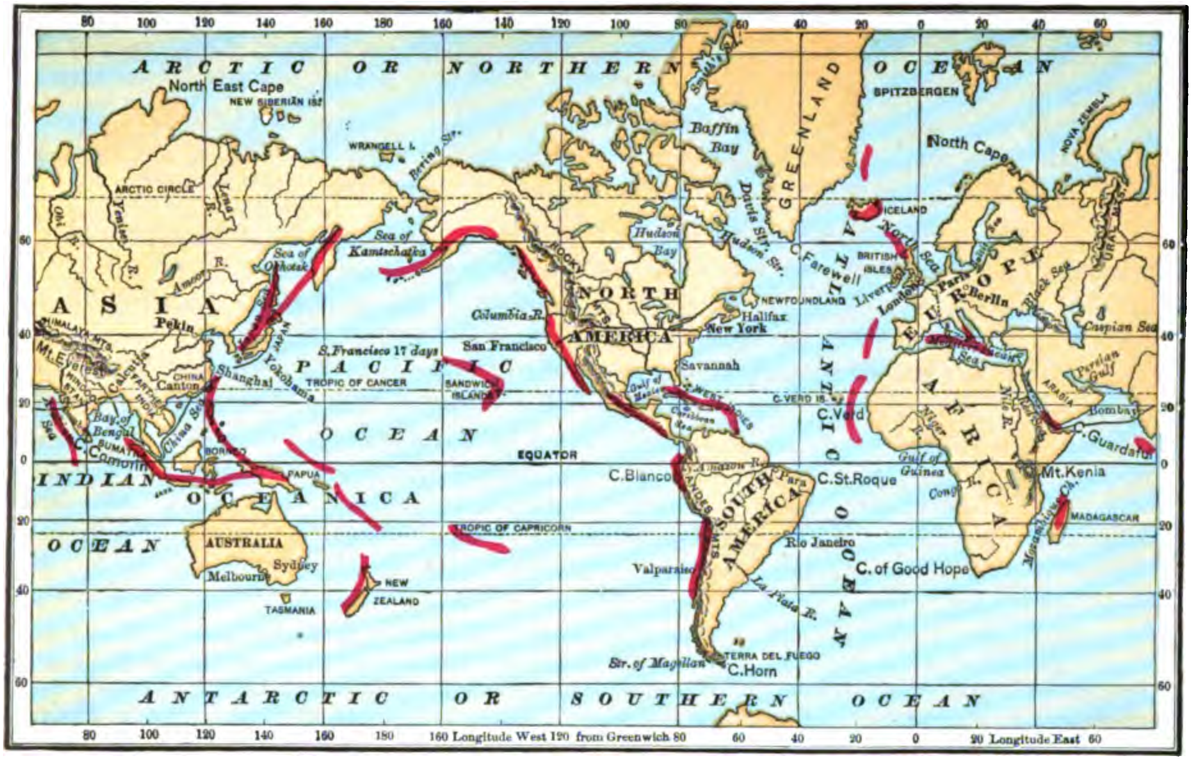
25. **Distribution of Volcanoes.**—The number of volcanic mountains on the Earth having well defined craters, exceeds 1,000; of these, about 350 show signs of activity. Of the active volcanoes, about 117 are situated on continents; the remainder are on islands.



New craters formed along the flank of Etna during eruption of 1865.

26. **Of the whole number** of volcanoes, fully nineteen-twentieths are on the islands and coasts of the Pacific ocean. By referring to the chart of volcanoes, a chain of volcanic mountains may be traced from the southern extremity of South America northward through the Andean and Rocky mountain systems.

[1] Volcanic gases, with the exception of steam, are generally combinations of sulphur and of chlorine.




Distribution of Volcanoes. **Red bands indicate lines of fissure.**

27. **This chain extends** to Asia through the peninsula of Aliaska and the Aleutian islands, and continues through the **chain of continental islands east of Asia.**

28. A few leagues to the northward of Australia, it is joined by another great volcanic fissure, which underlies the islands of Sumatra and Java, at present the grand center of volcanic force.

29. Notice also that this great chain of volcanoes and volcanic mountains incloses the division of Oceanica, **every island of which is a volcano.**

30. There are two well defined **volcanic chains** in the **Atlantic ocean.** One of these extends from the West Indies through the Lesser Antilles, and contains about 50 well defined craters.

31. Another begins with the volcanic rocks in Greenland, and passes southward through Jan Mayen (*yän-mī'-en*) island, Iceland, the Azores, the Canaries, and the Cape Verd islands. From this chain a branch extends through the Faroe islands to the north of Iceland. These volcanoes are situated in a submarine mountain range.

32. Another branch passes through the Mediterranean sea. Etna, Vesuvius, Stromboli, Graham's island, and a large number of others, are situated along this chain. They form another great center of volcanic activity.

33. **Utility.**—"Volcanoes are the safety valves of the Earth." The truth of this we can realize in studying the nature and the greatness of the forces constantly at work within the Earth's crust.

34. Were it not for these natural channels for the escape of pent-up forces, the crust of the Earth would be constantly in a state of convulsion.

35. **Earthquakes frequently precede** volcanic outbursts, and are often their only warning. Indeed, it is not improbable that the same forces which cause the latter are also the cause of the former.

36. **Occurrence.**—The most notable as well as the most destructive volcanic eruptions of which there is any record, have occurred among the Mediterranean and the Javanese groups. Of the first group, Vesuvius has been always the chief actor.[1]

37. In 1538, an eruption occurred in the Phlegrean Fields, soon building a mountain to the height of 500 feet. This cone was named Monte Nuovo.

38. In the same year, Graham's island, a volcano off the coast of Sicily, was lifted above the sea. During its short existence, its eruption was very violent, lava being thrown to a height of 200 feet. When the eruption ceased, the island began to sink, and within two years had wholly disappeared.

39. The most terrible eruptions have occurred in the Javanese group. The Javanese records mention an outburst in the 12th century, during which Java and Sumatra, then a single island, were separated and the strait of Sunda formed between them. The small volcanic island Krakatu, remained above the ocean level, however, and has shown more or less activity ever since.[2]

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[1] Prior to A.D. 79, no eruptions of Vesuvius had been recorded. The cities of Stabiæ, Herculaneum, and Pompeii (*pom-pay'e*) had been built at its base, and gardens and vineyards covered its sides nearly to the ramparts of the crater. In A.D. 63, a violent earthquake occurred which overthrew many buildings, causing considerable loss of life and destruction of property. The alarm consequent upon this disaster soon subsided, and for sixteen years there was nothing to arouse the fears of the people dwelling within the doomed cities.

On the 24th of August, A.D. 79, a column of dense smoke (volcanic ashes) was observed rising from the top of the mountain. The elder Pliny, then in command of the Roman fleet, desirous of learning the cause of the extraordinary occurrence, landed at Stabiæ and hastened at once to the villa of his friend Pomponius. As night came on, streaks of fire appeared on the sides of the mountain, and simultaneously with the darkening, showers of ashes, stones, and rain began to fall thick and fast.

Perceiving that the villa would be soon destroyed, Pliny and his friend, with their servants, endeavored to make their way to the harbor. Tying pillows on their heads to shield them from the increasing shower of stones, they attempted to reach the sea shore, hoping to regain the nearest vessel of the fleet. Before they had reached a place of safety, however, Pliny, overcome by stifling vapors, fell to the ground dead.

Morning dawned in the blackness of midnight. The air was still thick with falling ashes and loaded with sulphurous vapors. When, at last, light was restored, a scene of inconceivable desolation appeared. The cities of Stabiæ, Herculaneum, and Pompeii, as well as the beautiful villas and gardens dotting the mountain side, had disappeared—all buried with their inhabitants beneath the fallen ashes. For more than 1,600 years not a vestige of the ill-fated cities was found. In 1758, some workmen digging a well came upon a building which proved to be a theatre of Herculaneum. Since that time a large part of the city of Pompeii has been uncovered. From appearances, it seems probable the fatal shower occurred so suddenly that many of the inhabitants perished in their houses.

After this eruption, Vesuvius remained quiet for over 100 years. Since that time, about twenty eruptions have taken place, the last occurring in 1872. Professor Palmieri, who remained in his observatory on the side of the mountain during this eruption, describes the spectacle as "seeming as though the mountain were sweating fire at every pore." In all former eruptions of Vesuvius, little else besides ashes was ejected. Later ones have been marked by the ejection of immense quantities of lava.

[2] In August, 1883, "without any warning there was an outburst, and Krakatu vomited an ink-black cloud which soon involved the land in complete darkness. Then it began to rain scoriæ and dust, and in a very few minutes, the greater part of northern Bantam, a fertile and populous country, was destroyed. Tremendous explosions hurled volcanic matter to a distance of many miles; the sides of the volcano were blown into the sea, its structure collapsed, and the entire island slowly subsided. On the following morning, only half of the island was above the water's level." More than 100,000 people perished by this convulsion.

Iceland contains thirteen volcanoes, of which Hecla and Skaptar Jökul are the most noted. During an eruption of the latter in 1783, the lava ejected formed a stream 50 miles long, having an average breadth of 15 miles.

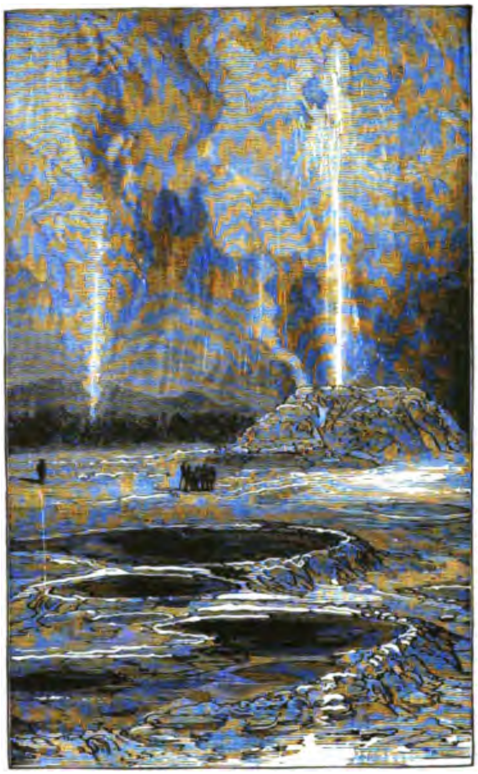
40. There have been several eruptions of Etna. The most destructive occurred in 1669, during which Catania was destroyed by the lava flood. Cotopaxi in South America, and Kilauea in the Sandwich islands are celebrated for their violent outbursts.[1]

41. **Mud Volcanoes.**—Mud volcanoes and geysers are both forms of volcanic energy, each being caused by subterranean heat. Except in the magnitude of their eruptions, they do not differ greatly from volcanoes.

42. **Geysers.**—Geysers are hot springs occurring in volcanic regions. At regular intervals, there is a gentle overflow of water at the surface; then a column of water is shot high into the air; and lastly, steam under great pressure escapes with a roar that may be heard for miles.

43. The geyser differs from other hot springs only in having an irregular, long tube reaching deep into the heated rocks.

44. **Structure.**—The geyser itself builds this tube from the silica, of which sand is a familiar example, which its waters dissolve while they are hot, and again deposit around the spring on cooling.[2]



Geyser in Yellowstone Park.

45. **Phenomena of Eruption.**—The water in the bottom of this tube may be heated many degrees higher than the boiling point of water, but because the pressure above is so great, the water cannot boil and hence steam cannot form.

46. By and by, the water in the center, or perhaps near the top of the tube, becomes so hot that great bubbles of steam form and force some of the water out at the top of the spring.

47. As soon as this takes place, the pressure at the lower part of the tube is removed, and the water, heated so far above boiling point, at once **flashes into steam.** This it does—not gradually, but *instantly*—and the force of the escaping steam throws a column of hot water often 200 feet or more into the air.

48. There are three regions where **geysers chiefly occur.** Iceland, New Zealand, and the Yellowstone Park northwest of Wyoming. The last, by far the most extensive, contains about 10,000 mud volcanoes, geysers, and hot springs.

49. **The geysers of the Firehole river** in this park are the most wonderful in the world. "The geyser basin is covered with snowy crystals of alkali and silica, often forming the most exquisite and fantastic designs."[3]

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[1] During 1883, Bogosloff, one of the Aleutian islands near Unalashka, and St. Augustin in Cook's Inlet—both volcanic islands near Alaska—were rent by terrible eruptions. The former was leveled nearly to the water's edge; the latter was split in twain.

[2] *Hot alkaline waters only* will dissolve sand. Bunsen found the waters of all the Iceland geysers to be alkaline, and that none but alkaline springs were eruptive.

[3] "In some places, the silica is deposited in a gelatinous condition to a depth of three or four inches. Trunks and branches of trees immersed in these waters are quickly petrified."—*Le Conte.*

50. There are seventy-one geysers in this region, from six of which the water is thrown to a height exceeding 150 feet.

51. **The Iceland region** contains about 100 geysers, of which the Great Geyser is the best known. Its eruptions occur regularly at intervals of an hour and a half, throwing a column of water eighteen feet in diameter to a height of one hundred feet.[1]

52. The crater or basin of the Great Geyser is more than fifty feet in diameter, and the surrounding wall is thirty feet in height. The tube is eighteen feet in diameter and extends to a depth of eighty feet.

## WHAT HAS BEEN TAUGHT IN CHAPTER VII.

*Volcanoes are channels opening from the interior to the surface of the Earth.*

*Out of this opening, molten rock or lava, hot gases, steam, and water are forced.*

*The substances ejected from the volcano build up a cone-shaped mountain about the opening, forming at the top a cup-like depression, called the crater.*

*With every eruption, not only is the size, position, and shape of the crater greatly changed, but often the whole mountain is changed in appearance.*

*The origin of volcanic forces is generally ascribed to the pressure of steam and other gases within the Earth.*

*The enormous pressure developed causes the crust of the Earth to give way at the weakest point, which is along the axis of a mountain system.*

*Volcanoes situated on the same range are frequently connected by subterranean channels, and the eruption often travels along the fissure formed by the broken crust.*

*Volcanoes are always situated near the sea coast.*

*The average volcanic eruption consists of: 1st, the blowing out of the crater floor and the discharge of steam, water, etc.; 2nd, the discharge of lava; 3rd, the escape of gases.*

*When volcanoes are constantly active, the eruptions are not violent.*

*The most violent eruptions occur after long periods of inactivity.*

*About 350 volcanoes are known to be active, 117 of which are on continental lands. The remaining 233 are on islands.*

*The most remarkable chain of volcanoes skirts the shores of the Pacific ocean, inclosing the division of Oceanica, every island of which is a volcano.*

*A chain of submerged volcanoes extends through the Atlantic ocean from Jan Mayen island, one branch of which extends eastward through the Mediterranean sea.*

*Mud volcanoes and geysers are forms of volcanic action, differing from volcanoes only in magnitude and violence.*

*The material ejected from geysers is always hot water, and the eruptions take place at regular intervals.*

*The water of geysers being alkaline, dissolves silica or sand. In cooling, the water again deposits the silica which it had dissolved.*

*The silica thus deposited finally builds an irregular tube, extending from the source of heat beneath to the surface of the Earth.*

*The eruption of the geyser is due to the sudden formation of steam from water that has been heated above the boiling point.*

*The principal geyser regions of the world are the Yellowstone Park in the United States, and Iceland.*

[1] There is a small geyser region in the Malheur valley, in eastern Oregon. They are true spouting geysers, but are insignificant in size and few in number. The geysers of Sonoma county, California, are not true geysers, but boiling mineral springs. They are not eruptive.

# CHAPTER VIII.

## EARTHQUAKES.

1. **Physical Phenomena.**—Earthquakes are tremblings or vibrations of some part of the Earth's crust. They are often connected with volcanic action, and it seems highly probable that both are caused by the same forces.

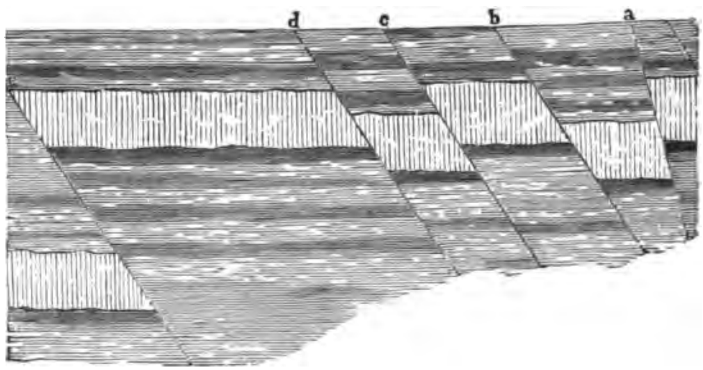
2. **Volcanic outbursts** are nearly always preceded by earthquakes, which cease after the eruption has occurred. The stoppage of volcanic action is frequently followed by disastrous earth-shocks.

3. When the smoke from Cotopaxi ceases to appear, the people of Quito (*keé-to*) are always in great dread of earthquakes. During the intervals when Vesuvius and Epomeo are both quiet, the surrounding country is subject to violent shocks.

4. Earthquakes sometimes occur in regions **remote** from all **volcanic centers.** These are undoubtedly brought about by the rising, the sinking, or by other movements of large masses of the Earth's crust.[1]

5. **Causes.**—The cause of earthquakes of the first type is attributed to the explosive formation of large volumes of steam or other gases in the hot interior of the Earth. Except in the magnitude of their effect, such earthquakes are not unlike the jar following the explosion of a great quantity of gunpowder.

6. Earthquakes of the second class are attributed to the gradual contraction of the Earth's interior, in cooling. The shrinkage of the heated interior is much greater than that of the overlying crust.




"Faults" caused by the Sinking of Broken Strata.

7. If the crust yields, the shrinkage will be gradual and unnoticed; but if it resists, by and by the increasing force becomes great enough to break or crush the resisting parts.

8. Such a breaking or crushing of large masses of earth is sufficient to produce the jarring or trembling that constitutes an earthquake.

9. **Analysis of Shock.**—If a stone be flung into the water, waves are produced precisely like those of the ground during an earthquake. At the spot where the stone strikes, the motion of the water is up-and-down. This movement makes a great number of circular waves, one outside of the other, which spread over a large surface.

[1] The coast of Chili was elevated from two to ten feet during an earthquake in 1835. An area of land exceeding 2,000 square miles in extent, lying near the mouth of the Indus, was wholly submerged by an earthquake occurring in the North Indian ocean. During a severe earthquake, which in 1811 occurred in the Mississippi valley, several large bodies of land near the mouth of the Ohio river, sunk, and to this day remain covered with water.

10. **Above the center** of the concentric circles, the motion consists of up-and-down vibrations, but at all other places on the surface, it gradually acquires a "rocking" motion. In the following diagram, it is shown how the vibrations of the earth-wave may differ in quality in different places.

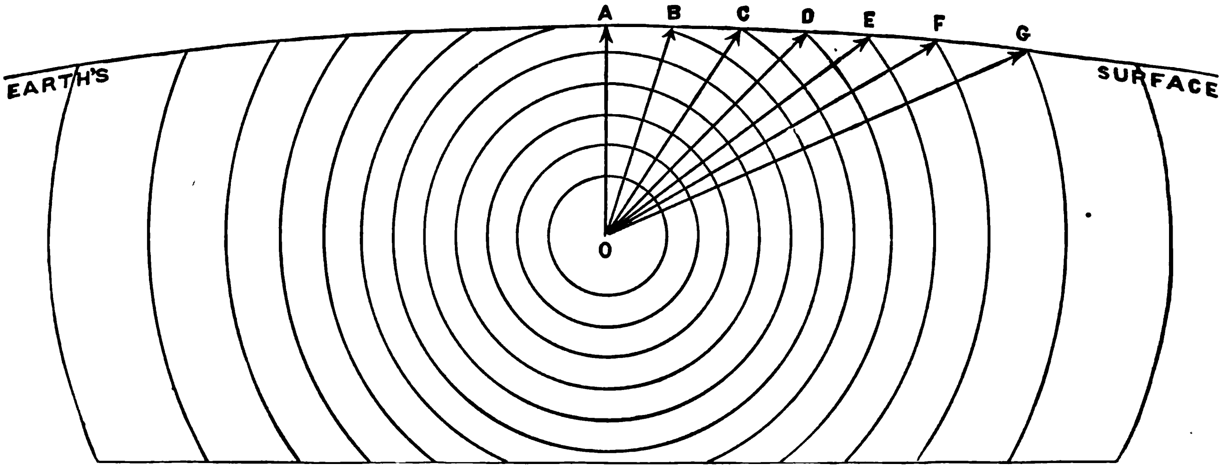



Diagram to Illustrate the Motion and Direction of Earthquake-waves.

11. For instance, the shock may have originated at O, the focus of the earthquake, some distance below the surface. When the waves reach the surface at A, directly above O, the vibrations are vertical, and are known as explosive or *vertical waves.* Waves of this character are very destructive.

12. **At some distance** from A, as E, F, and G, the waves will no longer be up-and-down; they will travel along the surface as *rocking* waves. These are called "horizontal waves of progression," or *spreading surface waves.* At a short distance from a point over the focus of the earthshock-waves, as at B or C, the waves partake of both the rolling and the vertical motion. Here the destructive effects are by far the greatest.

13. In a few instances, the ground has been twisted or whirled around, and buildings have been turned so as to face in an opposite direction. Earthquakes of this kind are very rare; they are usually known as *vorticose,* or whirling shocks, and are even more destructive than vertical waves.

14. **Velocity of Wave.**—The velocity of earth-waves varies, being much greater in hard than in loosely cohering rock. Careful experiments indicate an average of about nineteen miles a minute.

15. **Attending Phenomena.**—Subterranean sounds occasionally precede earthquakes. Sometimes, these sounds are like the roll of heavy wagons on the pavement; sometimes, like the sharp reports of cannonading; and now and then, it resembles the crunching together of rough surfaces of rock under immense pressure.

16. **Occurrence.**—According to Alexis Perrey, an average of nearly 600 earthquakes happen yearly. This number includes all earth-tremblings — even those imperceptible without the aid of instruments. It is plain, therefore, that in some part or other the Earth's crust is constantly quaking.

17. Because earthquakes are most frequent in winter and at full moon, it is thought that the attractive forces of the sun and the moon increase the strain on the Earth's crust, producing greater frequency of shocks.

18. **Distribution.**—Although earthquakes occur in all parts of the world, they are most frequent in volcanic countries, and along the **more recently formed mountain ranges.**


The Earthquake at Arica and the Tidal Wave following.

19. The regions in which earthquakes are most prevalent correspond closely to those of volcanic formation. The principal earthquake region of North America is on the Pacific coast, California especially being subject to frequent shocks. The Atlantic slope and the Mississippi valley, however, are occasionally shaken.

20. **Areas of Elevation and Subsidence.**—There are also changes of level in the Earth's crust which take place so gradually as to be imperceptible, except in long intervals of time. For instance:—

The eastern coast of **Greenland** is slowly **sinking.**

The coast of **North America,** in the region of Labrador, is **rising.**

The northern part of **Norway and Sweden** is **rising** at the rate of six feet per century.

The coast of **Florida** is slowly **sinking.**

The bed of the **Pacific ocean** in the region of Oceanica is **sinking.**

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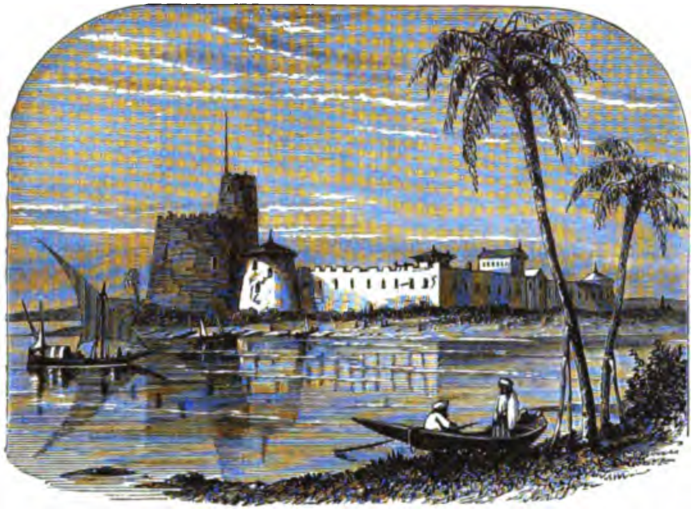
**Memorable Earthquakes.**—The earthquake at Riobamba, in 1797, was a striking example of both vertical and whirling shocks. The city was directly over the earthquake focus, and the earth-wave was fully twelve feet in height. Houses were thrown into the air, and the bodies of some of the victims were hurled to a height of a hundred feet across the river. Although the shock lasted a few seconds only, nothing but heaps of stones were left of a once beautiful city. More than 40,000 people perished.

The Lisbon earthquake of 1755 was frightfully destructive of life and property. At the moment of the first shock, most of the buildings were overthrown. The cathedrals were crowded with people, who had gathered there to witness the

ceremonies of All Saints Day. Here the loss of life was appalling. Multitudes made their way to the sea shore, hoping to flee from the crash of falling buildings; but an immense tidal wave, ninety feet in height, rolled in upon the shore and engulfed thousands whom the crash of the city had spared. Throngs had sought refuge on the new marble quay (*kē*), but scarcely had they reached it, before the quay and all who were on it sunk beneath the waters. The loss of life in this catastrophe exceeded 60,000 persons.



Fort Sindree before it was submerged by the Earthquake of 1819.

In 1868, there were a great number of violent earthquakes within the Pacific volcanic belt. South America, the Sandwich islands, and California, were all more or less disturbed. On the coast of Peru, the cities of Tacua, Iquique (*ē-kē' ka*), Arequipa (*ah-rā-ke'pah*), and Arica (*ah-re'kah*), were destroyed. In Ecuador, the town of Cotocachi (*ko-to-ka'che*), sank out of view, and a lake of great depth now covers its site.

The Calabrian earthquakes, during which so many Italian towns and villages were destroyed, seem to have been caused by the stoppage of Stromboli, as they promptly ceased when that volcano resumed activity. At the time of these earthquakes, several towns and villages entirely disappeared, being engulfed within the earth. Near Terranova, a chasm opened into which a part of the town fell to a distance of 300 feet. Throughout the whole Compartamente[1] the earth was greatly shaken. Great land-slides occurred; deep chasms opened; mud volcanoes and hot springs were formed; and in various places, bodies of land sank, the depressions being immediately filled with water.

In 1819, an area of 2,000 square miles about the mouth of the Indus, in Hindoostan, was suddenly converted, by an earthquake, into an inland sea. The fort and village of Sindree sank so much that only the tops of the fort, houses, and trees remained above the water.

On the 28th of July, 1883, a destructive earthquake occurred on the island of Ischia, in the Bay of Naples. The eastern part of the island, which is almost wholly built up by the lava from Epomeo, was the center of an earthshock which destroyed three towns. At Casamicciola, where the earth-waves were vertical, the shock was severest. The town was totally destroyed and 7,000 people perished.

Fort Sindree after the Earthquake.

A mild shock occurred August 10, 1884, which involved the New England and the Middle States, reaching as far west as Cleveland, Ohio. On Manhattan island,[2] the shock was vertical.

There are traditions among all peoples and in every language, of earthquakes that have been attended with the rising or the sinking of large areas of land. The Indians of the old San Francisco Mission believe that San Francisco Bay was once high above the water level, and sank during an earthquake. There is one legend of this kind, the story of Atlantis, that has more than ordinary interest. According to Plato, Atlantis was an island in the Atlantic ocean, opposite to the strait of Gibraltar. "It was the birth-place of civilization and the home of a mighty nation, whose people colonized all of the adjoining country. But in time, there came a great convulsion of nature, and Atlantis with its people sank into the ocean." It was the original seat of the Aryan or Indo-European family of nations, the Semitic and the Turanian races. Ancient Egypt, it is asserted, was the oldest colony formed by the Atlanteans, and from Atlantis, the Egyptians derived their civilization.

[1] District.

[2] Part of New York City.

Fissures formed during the Calabrian Earthquakes.

21. **The Tidal Wave.**—Tidal waves always follow earthquakes that originate near the ocean. These waves, however, must not be confused with the daily tides, with which they have no connection.

22. The tidal waves accompanying the Lisbon earthquake were ninety feet high when they broke upon the shore. Everything within their reach was destroyed.

23. After the earthquake at Arica, Peru, tidal waves sixty feet in height rolled in for several hours, destroying everything the earthshock had left. A United States iron-clad vessel was carried from the harbor and stranded upon the beach two miles from the shore. In several other instances, vessels at anchor have been tossed upon the shore and left hopeless wrecks.

24. The tidal wave is, without doubt, due to the up-and-down motion of the ground just above the focus of the earthquake. The wave following the earthquake at Arica traveled across the Pacific ocean, and in fourteen hours reached Japan, 10,000 miles distant.

## WHAT HAS BEEN TAUGHT IN CHAPTER VIII.

*Earthquakes are vibrations of some parts of the Earth's crust.*

*In most instances, severe earthquakes are connected with volcanic action, usually preceding it, and ceasing when the eruption has finished.*

*Earthquakes which occur in regions distant from volcanic activity are due to the gradual shrinkage of the Earth's crust in cooling.*

*The earthshock itself consists of a series of waves originating at a center, and radiating in every direction.*

*The earth-waves thus formed possess different qualities at different distances from the center.*

*Over the center of disturbance the motion is vertical. As the distance from the center of disturbance increases, the vertical gradually changes to a horizontal wave.*

*In several instances, whirling shocks have been noticed.*

*The velocity of the wave varies from 2,000 to 12,000 feet per second.*

*Earthquakes occur with greatest frequency in volcanic regions, and along newly-formed mountain ranges.*

*They are most frequent during winter months at time of full moon.*

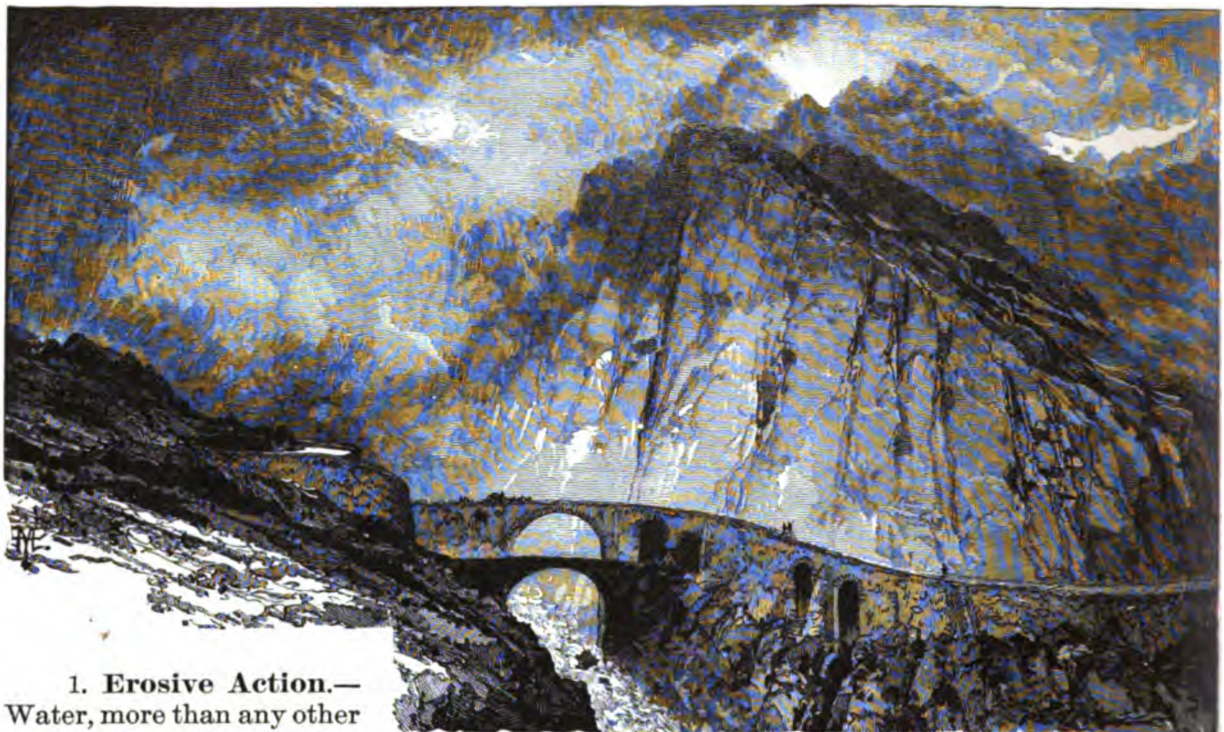
*There are other changes of level in the Earth's crust, so gradual as to be noticed only in long intervals of time.*

*Parts of Greenland, of Florida, and nearly the whole of Oceanica are sinking; while portions of Labrador, Norway, and Sweden are rising.*

*Ocean waves of great height, called* tidal waves, *frequently follow earthquakes, which occur near, or in the ocean.*

# CHAPTER IX.

## THE WATER OF THE ATMOSPHERE.



The Water of the Atmosphere.

1. **Erosive Action.**—Water, more than any other agent in nature, has worn and sculptured the surface of the land, and given to it its present diversified appearance and picturesque beauty.

2. **The hills** have had their tops rounded off, and the plains and valleys have been formed and smoothed over by water.

3. **Those vast prairies** of the Mississippi valley were made by the water of running streams, which brought the material from the Rocky and the Appalachian mountains to fill the ravines and level off the rugged surfaces.

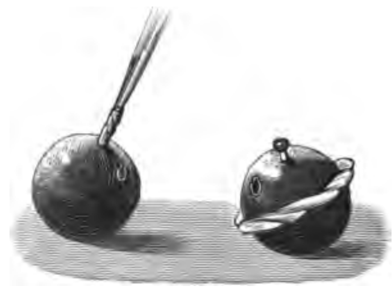
4. All of those immense deposits of **sedimentary rock,** sometimes measuring miles in thickness, have been worn away from older rock, pulverized, and distributed over the Earth's surface by water.

5. **Composition.**—Water is composed of two gases, hydrogen and oxygen, combined in the proportion of two volumes of the former to one of the latter. It freely absorbs air and other gases, and likewise dissolves many of the minerals of the Earth with which it comes in contact.[1]

[1] The oxygen *weighs* eight times as much as the hydrogen.

6. **Forms of Water.**—At ordinary temperatures, pure water is a colorless, tasteless **liquid.** At 32° F., it becomes a **solid,** or freezes; and at 212° F., it changes to **steam.**[1]

7. **Expansion.**—**The bulk** or volume of water is changed by heat. At 39° F. a pound of water occupies less space than at any other temperature; but as the temperature lowers to the freezing point, the volume increases very slightly—about one part in 400.



Expansion of water at the moment of freezing.

8. At the moment of freezing, the bulk increases about one-fourteenth. The expansive force of freezing water is irresistible. Iron shells having walls an inch thick have been burst by freezing the water with which they were filled.

9. **Above 39° F.,** the bulk of the water also increases with the temperature. Thus, if 100 gallons of water at 39° F. be heated to the boiling point, it will then measure nearly 110 gallons.

10. As water at the freezing point is lighter, bulk for bulk, than at 39° F., it is plain that when the temperature approaches the freezing point, that part of the water below 39° F. will rise, and the ice will form on the surface of the water instead of at the bottom.[2]

11. **Specific Heat.**—No other element on the Earth requires so much heat as water to warm it. The heat is slowly absorbed, and as slowly given out again. It follows, therefore, that all large bodies of water store up much of the sun's heat during summer and give it out in winter, thereby tempering the climate of both seasons.

12. **The heat** required to warm a pound of water from 32° F. to 212° F. would warm more than *nine* pounds of iron to the same temperature.

13. **Latent Heat.**—Whenever ice is melted a certain amount of heat is absorbed. For instance, if a vessel filled with ice at 32° F. be placed upon the fire, the temperature of the water will not rise above 32° F. *until all the ice has been melted.* A large amount of heat has disappeared, having been used in melting the ice. If the water be changed back to ice all of the heat again appears.[3]

14. **Utility.**—Without water, such forms of life as now dwell on the Earth could not possibly exist. Our bodies are three-fourths water; the food we eat is four-fifths water; the fruits of the tree and the vine are nine-tenths water. For many reasons, therefore, a wide distribution of water is necessary to the growth and prosperity of a people.

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[1] At all temperatures, to a certain extent, water turns to vapor. Even ice and snow evaporate, if the air be *dry.* The amount of water which air can thus hold in the form of vapor will be shown in another lesson.

[2] "Ice forms only at the top, the mass of water remaining at 39° F. Had water become heavier as it cooled down to the freezing point, a continual circulation would be kept up until the whole mass was cooled down to 32° F., when solidification of the whole would ensue. Thus our lakes and rivers would be converted into solid masses of ice which the summer's warmth would be insufficient to melt; and hence, the climate of our now temperate zone might approach in severity that of the Arctic regions."—*Roscoe.*

[3] When water boils, no matter how fierce the heat, the temperature remains at 212° F. until the whole of the water has evaporated. This is because the heat has been used to change the water to steam. But when the steam is again converted to water, all the heat is set free.

15. **Atmospheric Water.**—Every drop of water on the land, whether in wells or springs, lakes or rivers, has been brought from the ocean by the winds, which, taking it up in the form of vapor, pour it upon the land as rain. Let us learn the way in which this takes place.

16. **Air** has the property of taking up water in the form of vapor. We may notice that after a rain, the moisture soon disappears and the pools of water dry up. The air has absorbed the moisture, which the heat of the sun has changed to an invisible vapor. This process is called evaporation.

17. **Dew Point.**—The amount of water the air can hold, depends on the temperature of the latter. Warm air will contain a great deal more of moisture than cold air. When the air contains *all* the vapor it can hold, it is said to be **saturated,** or at the **dew point.**

| Temperature, Fahrenheit. | W't of Vapor, in Grains. | Temperature, Fahrenheit. | W't of Vapor, in Grains. | Temperature, Fahrenheit. | W't of Vapor, in Grains. |
|---|---|---|---|---|---|
| 0° | 0.55 | 65° | 6.79 | 96° | 17.65 |
| 10° | 0.84 | 70° | 8.00 | 98° | 18.69 |
| 20° | 1.30 | 75° | 9.37 | 100° | 19.79 |
| 32° | 2.13 | 80° | 10.95 | 101° | 20.36 |
| 40° | 2.86 | 85° | 12.75 | 102° | 20.94 |
| 50° | 4.09 | 90° | 14.81 | 103° | 21.53 |
| 55° | 4.86 | 92° | 15.71 | 104° | 22.15 |
| 60° | 5.75 | 94° | 16.54 | 105° | 22.77 |

18. When, however, the temperature falls below the dew point, the excess of moisture appears either as **rain, snow, hail, dew, fog,** or **clouds.** In the foregoing table, you will find the weight of water which a cubic foot of air, at different temperatures, may contain.

19. **Rain.**—If air at 100° F. pass over the ocean, it will absorb a great amount of moisture—nearly 20 grains per cubic foot. When this warm air strikes the cold mountain tops of some continent, its temperature is suddenly lowered—perhaps to 65° F.

20. But at 65° F., the air can hold only one-third as much moisture as at the former temperature. Hence the vapor is *condensed* or again changed to water, which, falling as rain, saturates and fertilizes the porous soil of the Earth.

21. The average annual rainfall of the United States is about 39 inches; that of Europe is 36 inches. The greatest annual rainfall occurs in the Himalaya mountains. Here, in certain regions, the rainfall has exceeded 660 inches in one year.[1]

22. **Snow.**—Snow is formed when the vapor of water passes directly into a solid state. It may therefore be called **frozen moisture.** Snow can occur only when the temperature is at or below 32° F.

23. Examined with the microscope, snowflakes are seen to be crystals of wonderful symmetry and beauty. Notice that each crystal is six-sided or six-pointed, and that the angles are similar.

[1] The *distribution* of rain will be considered in the chapter on climate.

24. **Hail.**—Hail is **frozen rain,** and is usually formed at a great height. Thunder and lightning often accompany hail storms. Ordinarily, hail stones are about the size of rain drops; but in many instances they are much larger, sometimes exceeding two inches in diameter.

Snow Crystals.

25. Hail storms are of very short duration—seldom lasting longer than ten or fifteen minutes, but they are always severe while they last. The severest hail storms of which there is any record, have occurred in the northwestern part of the Mississippi valley.[1]

26. **Dew.**—Dew is the moisture that collects in little drops on the leaves and the grass, during clear, still nights.

27. To understand why and how dew thus forms, we must again consult the table on page 58, to find how much moisture the air can contain at a given temperature.

28. If the temperature during the day is 80° F., the air may hold nearly 11 grains of moisture per cubic foot. But just after sunset, the surface of the Earth begins to cool rapidly—much more rapidly than the air.

29. When the temperature has fallen to perhaps 60°, the air near the ground, also cooled to the same temperature, can therefore no longer hold more than half as much moisture. The surplus is deposited as dew.

30. In the morning, as soon as the sun has warmed the Earth, it, in turn, warms the air, which can once more hold the moisture. Hence the dew soon disappears by the vaporization of the moisture which formed it.

31. Very frequently, there are nights during which **no dew forms.** If the sky be overcast with clouds, no dew will form, because the clouds do not permit the Earth to part with the heat it has stored up during the day.

32. **A strong wind** will prevent the formation of dew, because none of the air remains in contact with the Earth long enough to be cooled below the dew point.

33. Most frequently there is none deposited, because the atmosphere contains no more moisture than it can hold at the lowest temperature which occurs during the night—that is, the temperature does not sink to the dew point.

34. **Dew forms most copiously** in the vicinity of the sea coast, and in places well supplied with fresh water. There are some localities far inland, in which dew seldom or never forms.

35. **More dew** forms near the **ground** than at a short distance above it. This is because the temperature rises steadily as the distance from the ground increases.

[1] When a large hail stone is cut in two, it is found to be composed of alternate layers of snow and ice. The cause of this phenomenon is not known. It has been attributed to the whirling action of the wind, whereby the hail is carried successively into warmer and colder layers of air, receiving a coating of water in the former, which freezes, and of snow in the latter. This explanation is theoretical, and not at all satisfactory.

Various kinds of clouds. One bird in the illustration is in the Cirrus; two are in the Cumulus; three, in the Stratus; and four, in the Nimbus.

36. **Frost.**—Frost is frozen dew. Whenever the temperature falls below 32° F., the moisture deposited consists of minute icicles instead of small drops of water.[1]

37. **Fogs.**—Fogs are masses of vapor partly condensed, resting on the surface of the Earth. It is thought by some authorities that the minute globules composing the fog are hollow—that is, air bubbles of exceedingly small size; by others, it is claimed that they are very small drops of water.

38. Fogs prevail when the air is just below the dew point and cannot hold quite all of the moisture present. With a rising temperature, the fog disappears because the air can then hold a greater amount of moisture.

39. Fogs seldom reach more than four or five hundred feet above the ground—often, not half that height. An observer on a mountain may frequently see the valley below enveloped in a dense fog, while above him the sky is perfectly clear.

40. **Clouds.**—Clouds differ from fogs in position only, the latter resting on the ground, while the former are usually high in the air. Clouds are named according to their *form* and *appearance.*

41. **Cirrus[2] clouds** are those light, feathery clouds which sailors call *cat-tails.* They are always very high, and it is probable that they consist of minute ice crystals.

42. **Cumulus[3] clouds** are so called because they seem to be thrown up in heaps or piles. The cumuli are summer clouds, and are supported by the warm, ascending currents of air from the Earth. They begin to form after sunrise, are heaviest during the middle of the day, and disappear after sunset.

43. **Stratus[4] clouds** are the horizontal bands of cloud matter near the horizon, often

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[1] Frosts are far more apt to occur in valleys and river-bottom lands than on hill sides. The intelligent fruit-grower recognizes this fact, and selects a hill or a mountain side for his orchard, rather than the alluvial bottom lands. Orchards situated on a ridge of land, or on the foot hills, are seldom troubled by early frosts, while those on the bottom lands frequently fail year after year.

[2] *Cirrus.*—From the Latin *cirrus*, a feather.

[3] *Cumulus.*—From the Latin *cumulus*, a heap or pile.

[4] *Stratus.*—From the Latin *stratus*, a layer.

seeming to be arranged in layers. They usually appear at sunset, and sometimes continue through the night, but generally disappear at daybreak.

44. **The nimbus**[1] is the storm cloud. It is of a dark hue, and shapeless. It hangs low and covers the whole sky. The lower part of the nimbus cloud consists of raindrops; the central portion, of mist; and the upper, of fog, or cloud mist. Cumulus and stratus clouds may become rain clouds, as they differ from the nimbus in form only.

45. Cirro-stratus, cumulo-stratus, and cirro-cumulus are modifications of those already described. Cirrus clouds, especially when they are observed at sea, are often the forerunners of a storm. No other clouds are watched with such interest by sailors as the cirrus cloud.

46. **Economy.**—Were it not for the moisture of the atmosphere, both the heat of day and the cold of night would be intolerable. But the small amount of vapor—scarcely one part in a hundred—acts as a screen which intercepts the fierce heat of the sun during the day, and gives it out at night.

47. In intercepting and absorbing the heat of the sun, the moisture of the air is more than seventy times as powerful as the air itself.

48. In regions like the Libyan desert, where the air is unusually dry, the day temperature sometimes exceeds 140° F., while at night, water in shallow vessels may be frozen.

## WHAT HAS BEEN TAUGHT IN CHAPTER IX.

*The surface of the land owes its present appearance chiefly to the action of water.*

*Water is composed of two gaseous elements, oxygen and hydrogen, chemically combined.*

*Below 32° F., water is a solid; and above 212° F., a vapor.*

*Water requires more heat to warm it than any other substance occurring free in nature, and it also parts with its heat more slowly.*

*All fresh water in the Earth came from the ocean.*

*The air has the property of taking up water in the form of vapor.*

*The warmer the air, the greater the amount of moisture it will absorb.*

*When air loaded with moisture is cooled, it gives off the excess of moisture as rain, hail, snow, dew, fog, or clouds.*

*Dew is the moisture deposited on or near the ground when the air has slowly cooled below the point of saturation.*

*Air containing all the moisture it can hold at a given temperature, is said to be saturated.*

*Unless the air cools below the point of saturation, no dew is deposited.*

*Snow is formed when the vapor of water passes at once into a solid state.*

*Frost is frozen dew, forming only when the temperature of the air sinks below the freezing point.*

*Fogs are masses of vapor in a state of partial condensation, resting on or just above the Earth's surface.*

*Clouds are classified as Cirrus, or* feather *clouds; Cumulus, or* pile *clouds; Stratus, or* layer *clouds; and Nimbus, or* rain *clouds.*

*The small amount of moisture in the atmosphere being a poor conductor of heat, shields the Earth from much of the sun's heat during the day, and prevents much of the heat received during the day from escaping at night.*

[1] *Nimbus.*—From the Latin *nimbus*, a storm cloud.

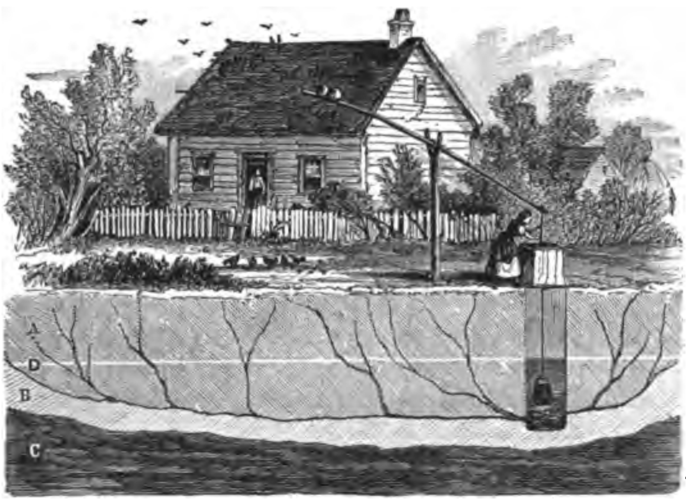
# CHAPTER X.

## THE WATERS OF THE CONTINENTS.

### SPRINGS AND LAKES.

1. **The water** which is raised from the ocean as vapor, and is carried away by the winds and poured upon the dry land as rain, evaporates, sinks into the ground, or else flows off upon its surface. When it flows off upon the surface, rivers, creeks, and brooks are formed; when it sinks into the ground, springs and underground reservoirs.

2. **Origin of Springs.**—A portion of the water which soaks into the ground sinks until it comes to a layer of hard rock or clay through which it cannot pass, while another portion is retained in the porous rock and soil, just as it might be held by a sponge.[1]



Section of the ground or rock, showing how wells are supplied.—A, The part through which the rain water percolates; C, Rock or clay impervious to water; B, Seam or stratum in which the water passes; D, Level of water in porous ground.

3. If a hole be sunk into water-soaked ground, it is immediately filled with water forced out by the pressure of water above and around it. In this manner, our wells are kept full.

4. If there are cavities in the ground, they also will be filled with water. When such cavities are on sloping ground, the pressure of water above forces it to the surface at a lower level.

5. The stream of water flowing from this channel is a **spring**. Sometimes, there is a cavity or underground basin in which the water collects, but quite as often, the whole supply is held in the porous soil, and trickles out through some channel which the water itself has made.

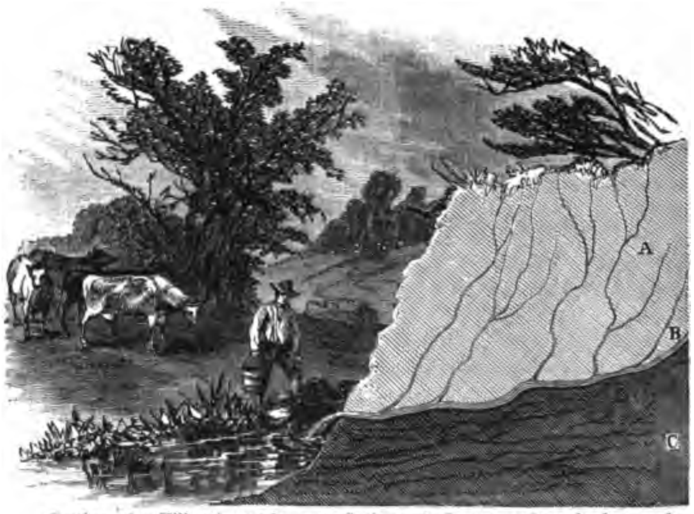
6. The water will flow so long as the level of the reservoir is higher than the spring. When this is no longer the case, as after a long drought, the spring ceases to flow.

7. Occasionally, the water from running streams finds a small passage-way under ground, and comes again to the surface at some distance from its starting point. Many of the springs on the prairies and the plains may be thus explained.

8. The picture on the next page explains how **springs are formed.** The porous soil into which the water soaks is underlaid by hard clay or by rock, through which it cannot readily pass.

[1] Light, porous soils and sandstones will hold *nearly half their bulk* of water.

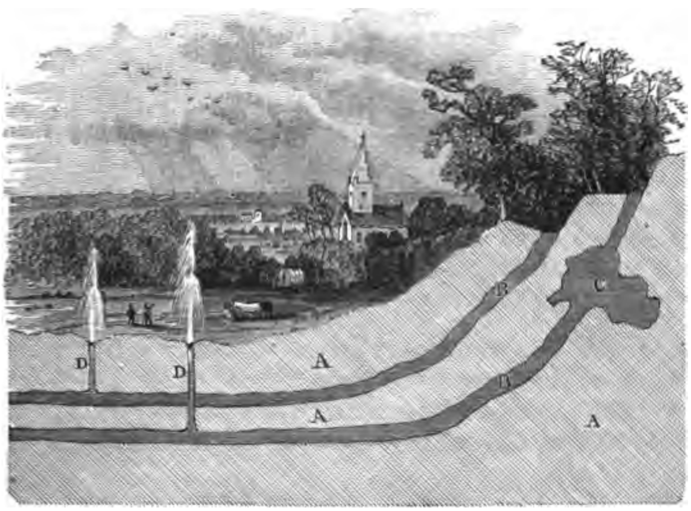
9. **Artesian Wells.**—When an underground reservoir is tapped by drilling or boring through the overlying rock, the pressure is often so great as to force the water above the surface. These artificial channels are called artesian wells.[1]




Section of a Hill, whence issues a Spring.—A, Loose earth or broken rock through which the water sinks; C, Solid rock or hard clay not penetrated by water; B, Seam or channel in which the water flows.

10. Artesian wells have been sunk to great depths—2,300 feet or more—in order to reach underground streams of water. Sometimes the water spouts above the surface, but oftener it does not quite reach to the top of the ground.

11. **Hot Springs.**—In ordinary cases, the temperature of spring water varies from 50° to 60° F.; but in many places, there are springs whose waters are hot and even boiling.




Artesian Wells.—A, A, A, Strata impervious to water;—B, B, Seams or strata of porous rock saturated with water;—D, D, Borings in the ground or rock, called artesian wells.

12. **Their heat** is derived either from the chemical decay of rocks, or else from the heated volcanic matter surrounding the reservoir. Most of the known hot springs are in volcanic regions.

13. **Mineral Springs.**—The waters of many springs, in trickling through porous rock, dissolve and retain the more soluble minerals, such as salt, carbonate of soda, lime, and various combinations of sulphur. They are commonly called "mineral" springs.[2]

14. Mineral spring waters usually are hot, but some of the most celebrated in the world, as those of Saratoga, New York, and Seltzer, Germany, are cold springs.

[1] In that part of southern California lying between the coast mountains and the Pacific ocean, there are several thousand artesian wells, ranging from 100 feet to 1,200 feet in depth. The first of these were spouting wells, but the number is now so great, that but few of them force the water above the surface. By their means, millions of acres of land are now fruitful which would be unproductive without them. A number of artesian wells have been successfully driven in the Great Desert by the orders of the French Government Survey.

[2] Mineral springs may be calcareous, containing carbonate of lime; soda springs, containing soda; silicious springs, or geysers, containing silica or sand in solution; sulphur springs, containing hydrogen sulphide or other sulphur compounds; chalybeate springs, containing iron; acid soda springs, containing large quantities of carbon dioxide. The latter are always *cold springs.* "Seltzer," "Vichy," and "Congress" waters are taken from such springs.

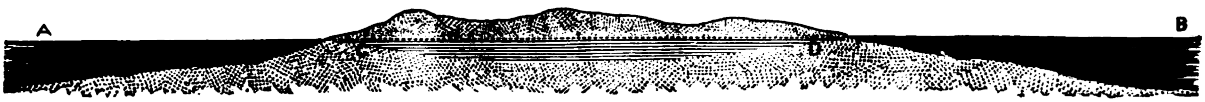
15. If carbonate of lime be present in the water of a spring, much of it is deposited. If the water fall drop by drop, icicle-shaped deposits called **stalactites** are formed at the ceiling, while similar deposits called **stalagmites** are built up from the floor of the cavity.[1]

16. **Mineral Oil Springs.**—In California, Pennsylvania, Syria, and Turkestan, tar and petroleum springs abound. In the island of Trinidad, near the mouth of the Orinoco, the accumulations of bitumen[2] or mineral "pitch" have formed a large lake.

17. **Periodical Springs.**—Periodical or intermittent springs are those whose waters flow at irregular intervals. It is thought that their irregular flow is due to the siphon-shape of the channel through which the water is discharged.

18. **Water Supply of Islands.**—Supplies of fresh water are usually found even on small islands—especially coral islands. Wells may be sunk from which fresh water is obtained, even though the surface of the water in the well be no higher than the level of the surrounding ocean.

19. The explanation of this apparently strange fact is simple. After a heavy rain, the water sinks into the sand, and being lighter than the sea-water, rests upon it, as is shown in the accompanying cut.




A, B, Sea level;—C, D, Fresh water from rain resting on salt water, with which it does not mix because it is lighter.

20. **Formation of Lakes.**—Much of the water that does not evaporate or sink into the soil collects in natural depressions of land.

21. If it collect in this basin or depression more rapidly than it evaporates, **a lake is formed.** The water either continues to collect until it rises to the rim of the basin and overflows, or else it spreads over the land until it covers a surface so great that precisely as much evaporates as flows into the basin.

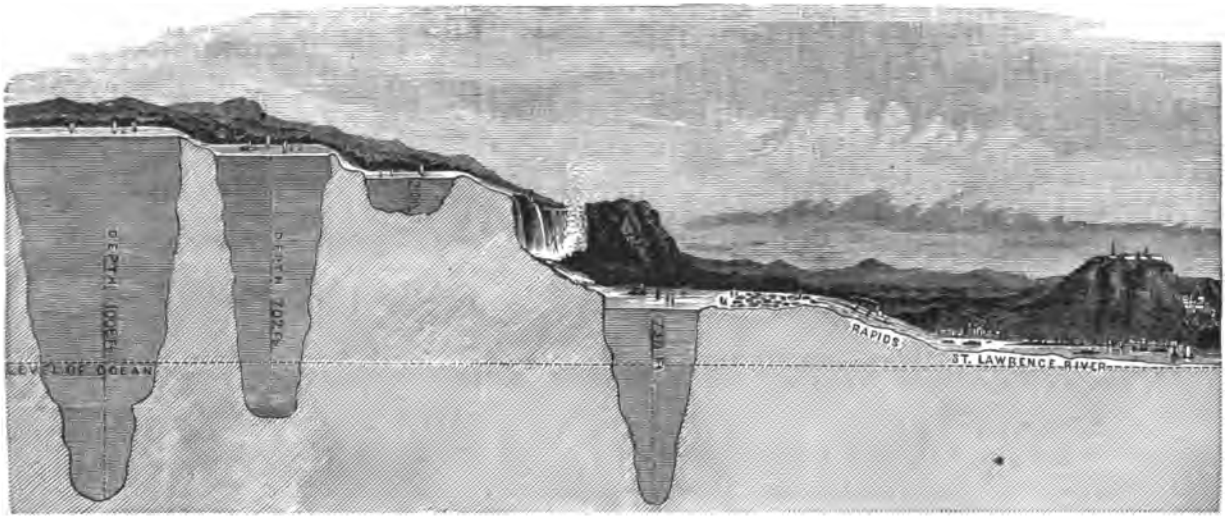
22. **Classification.**—Thus we see there are two classes of lakes—**those having outlets and those having none.** The waters of the former are fresh; those of the latter are usually salt. The latter are met with in great continental plains, where there is but little chance for their waters to run off. For this reason, the lakes occurring in such regions are commonly called "steppe" lakes.

23. Each continent has its lake-systems. The largest is in North America, which alone contains a greater number of lakes than all the other continents together.

24. **Lakes of North America.**—The Great Lakes of North America have an area of more than 100,000 square miles—scarcely less than the combined area of all the remaining bodies of fresh water in the world. The basins drained by them, however, are but little larger than the lakes themselves, as each basin is filled nearly to the brim.

[1] The material thus deposited is usually known as *travertine*. Twigs, medallions, coins, etc., placed where they can be sprayed with the waters of these springs, are quickly covered with a deposit of carbonate of lime. The so-called *petrified moss* consists usually of the fine rootlets of plants covered with accretions of limestone.

[2] This substance, variously called "pitch," "asphalt," and "brea," is much used in street-paving, for making a tough, artificial building-stone, and also as a covering for foundation-walls.




**Lake Superior. St. Mary's River. Lake Huron. Lake Erie. Niagara River and Falls. Lake Ontario. 1000 islands. Montreal. Quebec.**

**A Sectional View of the Great Lakes and the St. Lawrence River, looking North.**

25. The water of these lakes is supplied chiefly by rain, but partly by a few small rivers. The average rainfall in the region of the lakes is 36 inches a year—an amount sufficient to keep them full and to supply the St. Lawrence river, their outlet.

26. The situation of these lakes, in terraces, one higher than another, is an interesting feature. The rivers draining the waters of these lakes contain falls and rapids.

27. **Lakes Superior and Huron,** the deepest of this group, have a depth of 1,008 and 702 feet, respectively. The bottom of the former is 409 feet below sea level.

28. **Lake Erie** has an average depth of less than 70 feet. A severe storm stirs its waters to the bottom. For this reason, and also because there is so little sea room, Lake Erie during a storm is a very dangerous body of water for sailing-vessels.

29. A chain of smaller lakes lies northwest of the Great Lakes. Indeed, so closely connected are the lakes, that water communication between Lake Superior and Hudson Bay is sometimes possible for canoes.

30. **An arc of a great circle** drawn from a point a few miles west of Buffalo to the western side of Geography island, near the mouth of the Mackenzie river, will pass through nearly all of the more important fresh water lakes on the continent.

31. **African Lakes.**—The principal lake system of Africa is in the eastern part of the continent, at an elevation varying from 3,000 to 5,000 feet above the sea level. Like the Great Lakes, their basins are filled to the brim.

32. The lakes of Africa are in comparatively **unexplored regions.** Most of them are drained by the Congo or Livingstone, and Nile rivers. The principal are Victoria, the largest in the world, Albert, and Tanganyika (*tahn-gahn-yee'kah*).

33. **Lake Tchad** (*chad*), a fresh water lake in Soudan, has an area varying from 15,000 to 50,000 square miles, the latter being its area during the wet season. At high water it overflows, the Bahr-el-Gazel being its outlet.

34. **Lakes of South America.**—There are but two lakes of considerable size in South America, Maracaybo (*mah-rah-kī'bo*) and Titicaca (*tit-e-kah'kah*). The latter has an altitude of 12,000 feet.

35. **Lakes of Europe.**—The lakes of Europe form two groups. Those in the Alpine region are renowned for their beautiful scenery. The second group is situated in Russia, Lake Lad'oga being the largest. Most of the latter group are steppe lakes.

36. **The water of lake Elton,** in Russia, contains about twenty-nine per cent. of salt. In summer, many of the smaller steppe lakes of Russia dry up, leaving beds of salt and other mineral matter.

37. **Lakes of Asia.**—Lake Baikal (*bi'kahl*), in Siberia, is the largest fresh water lake in Asia. Its waters are frozen six months in the year. Lake Sirikol, the source of the Oxus river, has an altitude of 15,600 feet above the sea level.

38. **Lakes of Australia.**—Most of the Australian lakes are steppe lakes. They are situated in the southern and southwestern part of the continent. Lakes Eyre, Gairdiner, and Amadeus, are the most important.

39. **Salt Lakes.**—Of the various salt lakes, the Caspian, Dead, and Aral seas, and Great Salt Lake, are the most noted. The first two are below the sea level.

40. **The Caspian** and **Aral seas** are thought to have been, in recent times, arms of the ocean; but the fact that their waters are much fresher than those of the ocean, makes this theory somewhat doubtful.

41. The Caspian sea receives the waters of the Ural, Volga, and several other large rivers. The water supplied by these rivers is equal to the amount lost by evaporation.

42. The basin of the Caspian sea is a very large one and seems to be of recent formation. Petroleum, tar, and naphtha springs are numerous throughout the neighborhood of the sea. Its surface is eighty-four feet below the ocean level.

43. During certain periods, large quantities of naphtha and petroleum accumulate on the surface of the Caspian sea. In 1869, an extensive and destructive conflagration occurred by the accidental ignition of these substances.

44. **The Dead Sea,** whose surface is 1312 feet below the ocean level, is the most remarkable depression in the world. It is situated about eighteen miles east of Jerusalem, and extends over an area of 400 square miles.

45. The region in which it is situated is **volcanic** and is still subject to earthquakes. There is strong evidence that this depression was formed about 1900 B. C., during an earthquake accompanied by volcanic action.[1]

46. The river Jordan is its only inlet of any importance, and it has no outlet. The basin is a long one, but very narrow—hardly twenty-five miles in width.

47. The water level, during the rainy season, is about ten feet higher than in the dry season of the year. This enormous surplus is evaporated during the hot summer months, at which time the average temperature in the vicinity of the lake is about 93° F.

[1] The site of the Dead Sea is the Vale of Siddim, which Lot chose for his habitation when he parted from Abraham. Its climate was then vastly different from that of the present time. There were formerly two cities of considerable importance—Sodom and Gomorrah. These were destroyed in the convulsion of nature, described in Gen. xix, 28. The ruins of the ancient city, Zoar, have recently been discovered near the western shore.

48. There is some evidence that the rainfall in Syria has been steadily decreasing during the last 2,000 years. Should this continue, the drying up of the Dead Sea is a question of time only.

49. **Sulphur,** gypsum, pitch, and petroleum are found near the borders of the Dead Sea. There is but one other body of water in the world (Lake Elton) which contains so much of mineral salts in solution; every 100 lbs. of water contain 26 of salt.

50. **Great Salt Lake.**—Great Salt Lake of Utah is another remarkable example of the steppe lakes. That the area of this lake was formerly much greater, may be seen by the old shore lines, 900 feet higher than the present water-level. For the last twenty-five years, however, there has been a steady increase in its depth.

51. There are several streams of water flowing into Great Salt Lake; the Jordan (of Utah) is the largest. The soil, for many miles about this lake, is impregnated with lime, soda, and potash, all of which are carried into the lake by tributary streams.

52. **Origin of Salt Lakes.**—We can now understand why the waters of those lakes which have no outlets are salt. Soils and rock contain small quantities of salt and other minerals which are dissolved by the water as it flows through them.

53. If the water flows into a lake having no outlet, it evaporates and leaves the salt; but if there is an outlet, both water and salt are carried to the ocean.[1]

## WHAT HAS BEEN TAUGHT IN CHAPTER X.

*Springs are formed by the water which, falling as rain, sinks into the Earth.*

*The water sinks until it meets a layer of clay or of rock, through which it cannot pass.*

*It collects in underground reservoirs and channels, or saturates the porous soil.*

*When it emerges to the surface, the escaping water is called a spring.*

*Underground streams of water are often tapped by boring through the overlying strata. The artificial springs thus formed are called artesian wells.*

*Spring waters have usually a temperature varying from 40° to 60° F.*

*In volcanic regions, the temperature of their waters, owing to their contact with heated rocks, is often hot—sometimes even reaching the boiling point.*

*When the subterranean waters take up the soluble substances of the rocks through which they pass, mineral springs are formed.*

*Lake-basins are natural depressions in the Earth's surface in which rain-water collects.*

*If the water collect more rapidly than it evaporates, a lake is formed.*

*Lakes are of two classes—those which have outlets and those which have none.*

*The waters of the former are fresh; those of the latter, usually salt. The salt is dissolved from the soil through which the water flows.*

*The Great Lakes of North America constitute the largest body of fresh water in the world.*

*The lake system of Africa ranks next in size to that of North America.*

*The lakes of Asia and western Europe are chiefly steppe or salt lakes.*

*The Dead and Caspian seas are below the ocean-level.*

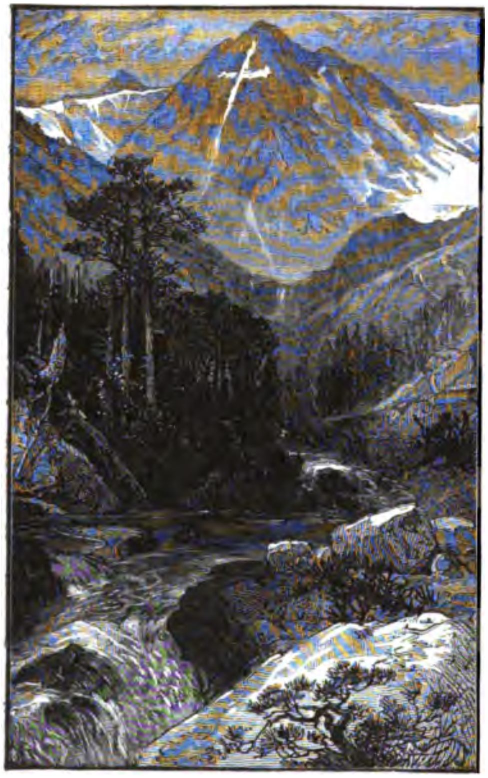
*The Caspian sea is the largest salt lake in the eastern hemisphere.*

*Great Salt Lake of Utah is the largest salt lake of the western hemisphere.*

[1] Well and spring waters also contain salt, although the amount is so small that it cannot be detected by the taste.

# CHAPTER XI.

## RIVERS AND DRAINAGE.



A Mountain Stream.—The Upper Course.

1. **The water** falling on the land in the form of rain and snow is sufficient to cover the continents to a depth of three and one-half feet each year.

2. Of this amount, perhaps two-thirds evaporates, and the remaining third flows back to the source from which it came—the ocean.[1]

3. **The Beginning of a River.**—The sources of most rivers are in mountains, for here is the heaviest fall of rain and snow; here, also, springs are most abundant.

4. The water that trickles from a spring or is let loose from some snow drift high on the mountains, forms a little rill which rushes down the steep slope toward the plain below.

5. On its way, it is joined by other rills in their journey to the ocean. The rivulet thus formed tumbles down the mountain slopes and over the pebbled bottoms of the gullies which it has worn.

6. **Other streams** swell it to a mountain torrent. Plunging over cliffs in cascades, or rushing down steep inclines in rapids, it cuts a channel into the hardest rock, and either tosses aside or else ploughs through obstacles happening in its way.

7. After a long and tumultuous passage, it reaches the plain at the base of the mountains, where it receives the waters of other streams that have had a similar journey.

8. Henceforth the conduct of the river is wholly changed. No longer able to carry the load of silt and gravel which it has scoured from the bottom and sides of mountain gorges, it drops all but the lighter portion and flows around obstacles which it cannot move.

9. So long as the current is swift it will carry this sediment, but check it ever so little, and some of it sinks to the bottom to form a bar or "shallow."

10. **The Middle Course.**—When the stream has reached the lowlands, it is still heavily laden with silt. At St. Louis, the river—if we take the Missouri and Mississippi as an example—is still 1,300 miles from the Gulf, and 375 feet above the sea level. From St. Louis,

[1] The foregoing statement must be considered as an average only. In certain regions, such as the Great Desert and Central Asia, nearly or quite all of the water disappears by evaporation; while in northern Asia and North America, the water which evaporates is less than one-fifth of that which falls.

the river flows with slightly decreasing velocity, on ground which it has itself spread over the valley. There are no banks that it has not built for itself, and having built them, it can just as easily cut them away.

11. **The Lower Course.**—In time, the waters reach the Gulf of Mexico, after a continuous passage of 4,100 miles. Here, the current is checked by the ocean tides, and the restless waters throw down the last remnant of their burden of silt.

12. Thus we see that a river course may consist of three parts: the upper course, where its work is **erosive,** or wearing; the middle course, in which it is chiefly **transporting,** or sediment-bearing; and the lower course, where it **builds up land** with the sediment brought from the upper course.


A River.—The middle course.

13. **Effect of Velocity.**—A river whose current flows with a velocity of four miles an hour will carry sixty-four times as much sediment as one flowing at the rate of two miles an hour; consequently, a slight change in velocity makes a very great difference in its carrying capacity.[1]

14. **Filling the Channel.**—Sediment is dropped in the lower course, because the current is checked; and because the sediment is dropped, it is plain that the channel must constantly fill up.

15. In time, the river has built its bed and its banks until they are higher than the surrounding land. Until a season of high water, however, it still flows in its channel.

16. Then it overflows, cutting away the banks that it had itself placed there. Through this break, or *crevasse,* the waters are poured over the surrounding lowlands.


A River.—Making a new channel.

17. **The New Channel.**—After the high waters have subsided, the river no longer flows wholly in its old channel. In various places, it has made a new one; and wherever the channel has changed, the river at that point has selected its bed in lower ground.

18. In this new channel the filling process immediately begins, and continues till another freshet turns its waters elsewhere. Thus has the work progressed for centuries.

19. **Shifting of the Channel.**—During past ages, the waters of the Mississippi river

[1] "It has been calculated that a velocity of three inches per second will tear up fine clay; that six inches will lift fine sand; eight inches, sand as coarse as linseed; and twelve inches, fine gravel; a velocity of twenty-four inches per second is required to sweep angular stones of the size of a hen's egg."

The Lower Course of a River.—Dropping its burden and forming a delta.

must have flowed in all parts of the valley — working in the same manner that it works now—building its banks higher than the surrounding land, and then breaking through them.

20. So long as the Mississippi flows, it will still bear its burden of silt to the Gulf of Mexico, and the latter will decrease in size until it is dry land.

21. The territory north of the gulf was formerly an arm of the sea as far north as St. Louis—or farther. All of that land has been formed from the silt brought down and deposited by the waters of the river.

22. **The lower course** of most rivers—especially those flowing through level plains—is usually very crooked and winding. The distance from St. Louis to the mouth of the Mississippi in a straight line is 700 miles; by the river channel it is 1,300 miles.

23. Were the river to flow in a straight line, its fall would be 7 inches per mile; but, flowing in its present course, the fall is less than 4 inches per mile.

24. Why it does not straighten its channel and thus increase its velocity seems strange, until we consider that the current is so slow that the water cannot carry even the burden it already holds. Hence, it drops the load and must ever afterward flow around it.

25. **Building the Valley.**—Thus we see that while in the upper course a river tends to straighten its channel, in the lower course it constantly lengthens it.

26. The sediment carried from the uplands by rivers is enormous. In places, the deposits are more than 1,000 feet deep. Much of the Great Central Plain has been built by the Mississippi and its tributaries.[1]

27. **Bars.**—If the mouth of a river face the tide wave, a bar is nearly always formed, because the silt brought down by the river is forced back by the tide, and cannot be carried far off shore by the river.

[1] "It must have been but yesterday that the mound-builders wrought in the valley, for in the few centuries that have elapsed since then, the surface of the ground has risen only a few feet—not enough to bury their works out of sight. How long ago, then, must it have been that the race lived there, whose pavements and cisterns of *Roman brick* now lie seventy feet under ground? And if we cannot answer this question, how shall we figure up the sum of years it has taken to fill up the valley a thousand feet deep with silt."—*D. A. Curtis.*

28. Bars thus formed are especially dangerous on the western coasts of continents. Those at the mouth of the Columbia river and the entrance of San Francisco bay are much feared by pilots.

Chasm of Tugaloo River, Georgia.

29. If, however, the tide wave sweeps at right angles to the current of the river at its mouth, much of the silt will be borne away, while, if the tide be not strong, that which remains may form a delta.

30. **The Delta.**—The figure on page 70 shows the manner in which a river extends its channel into the sea. The network of mouths and islands is called a "delta."[1] There the river drops the last of its silt.

31. The stream must now force its way through the mud flats which are constantly growing in size, and its waters must twice a day be pushed back by the tide. For this reason, little or none of the sediment can be carried beyond the delta.[2]

32. About 7,500,000,000 cubic feet of sediment are brought down yearly by the Mississippi river—enough to cover a square mile of land to the depth of more than 270 feet.

Tocoa Falls, Georgia.

33. Thus, for more than fifty miles the Mississippi has pushed its way into the sea, bordered on each side by narrow strips of land. These border strips are natural levees made by the river itself.

34. The Po, in northern Italy, is remarkable for the rapidity with which it has built its delta. Since the time of Augustus Cæsar, this delta has been pushed seaward 20 miles. During the reign of that emperor, the town of Adria, now 20 miles inland, was a seaport.[3]

35. **Rapids and Cataracts.**—It sometimes happens that the water of a river descends abruptly from a higher to a lower level. This is accomplished either by falls or by rapids.

36. If, in the higher level, there is a surface-layer of hard rock, a fall or cascade is the result. But if the upper surface is soft and easily worn away, rapids are formed instead.

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[1] *Delta.*—The name of the Greek letter D, made thus, Δ.

[2] The delta of the Mississippi river has an area of 14,000 square miles; the deltas of the Nile and the Ganges cover an extent of 20,000 square miles each.

[3] In order to guard against overflows, the lower course of the Po has been flanked by levees until the present bed of the river is much higher than the land on either side, owing to the constant deposition of sediment. Certainly a time must come when the levees will break and the channel of the river change. The same policy of levee building has been adopted in the case of the lower Sacramento river, where to the natural accumulation of sediment have been added the "tailings" from the hydraulic mines. With the lower Mississippi, a different plan has been followed. Here, the levees and jetties have been constructed in such a manner as to *increase the velocity of the current*, thereby forcing the water to scour out the channel instead of filling it. This carries silt out beyond the delta.

Lachine Rapids, St. Lawrence River.

37. The cataract between lakes **Erie** and Ontario, where the Niagara **river** falls to a lower terrace, is one of the most celebrated in the world. The Yosemite falls, in California, are an **extraordinary** example of mountain **cascades**; one of them having an uninterrupted fall of 1,500 feet. The total descent of the water is about 2,600 feet.

38. The falls of the Zambeze, about 360 feet in height, rank next to those of the Niagara river. The Cascade mountains are celebrated for the number and beauty of their waterfalls. The Cascades of the Santiam, Willamette, and Columbia rivers, of Oregon, are unsurpassed for their beauty and grandeur by any others in the world.

39. **Erosive Action.**—The wearing or erosive power of rivers is almost beyond belief. The cañon of the Colorado has been cut almost vertically to a depth, in many places, of more than a mile.

40. Deep gorges, sometimes exceeding 3,000 feet, have likewise been cut by the Columbia river and its tributaries. The cañon of Crooked river is especially notable.

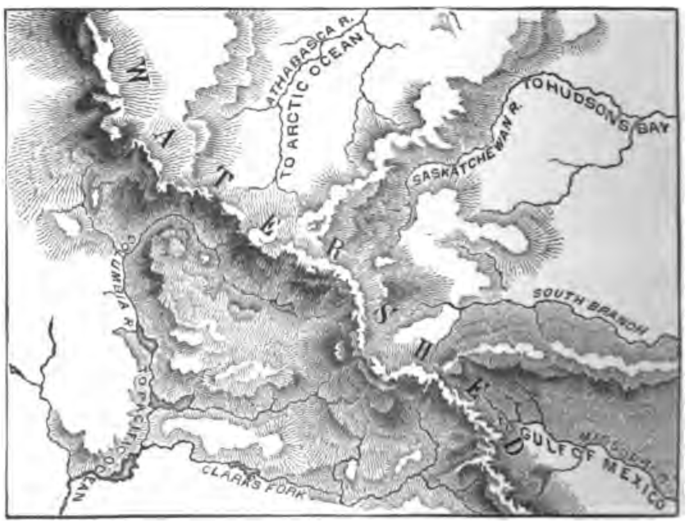
41. **River Basins.**—A *river system* comprises a river and all its branches. The surface of land drained by a river system is its *basin* or *territory.*

42. **The rim** of a river basin is called a watershed or **divide.** Generally, the divide is a mountain range, but sometimes it is an imperceptible ridge in some plain.

43. **Divides.**—The Height of Land which is the divide between the Great Lakes and the Mississippi river is a plain. The water taken from Chicago river to feed a canal discharging into a tributary of the Illinois, is lifted by machinery but *five feet.*

44. The most notable divide of North America is in the Rocky mountains. Separated by a few miles are the sources of the Missouri, the Columbia, the Athabasca, and the Saskatchewan.

45. **Drainage.**—North America contains several large drainage basins, of which the Mississippi is the most important and the largest. East of the Appalachian system the slope is drained by numerous, short rivers flowing into the Atlantic ocean.




The Great Continental Divide.

46. **The rim of the Mississippi basin** is formed by the Rocky mountains, the Height of Land, and the Appalachian mountains. This basin covers an area of one and a quarter million square miles.

47. **The Pacific slope** is drained by the Yukon, Columbia, Sacramento, and San Joaquin (*wah-keen'*) systems. The Yukon river is second to the Mississippi only, in volume. Its course, though, is in an unexplored region.

48. A few river basins, such as the Humboldt, the Mojave (*mo-hah'-ve*), and the Amargosa—all in the Great Basin—have no outlet to the sea.

49. **Of South America, the great drainage basins** are the Amazon, the Orinoco, and the La Plata. During the rainy season, the channels of the Amazon and the Orinoco are not large enough to carry off the surplus waters. Hence their plains are often flooded. West of the Andes, the slope is abrupt, and the rivers are short. There are no well-defined basins.

50. **In Africa,** the principal river basins are those of the Nile, the Livingstone or Congo, the Zambeze (*zăm-bā'-za*), and the Niger (*nī'-jer*). The Nile carries off the surplus waters of lakes Albert and Victoria, situated 3,800 feet above sea level. The yearly rise of water floods a large area of the Nile valley, covering it with a layer of rich soil.

51. **The drainage basins of Europe,** though numerous, are much smaller than that of the Mississippi. Those of the Volga and the Danube are the largest. The basins of the Rhine and the Rhone are the most important. The principal divide of Europe occurs in the plains, and is formed by the slopes of the Valdai Hills. The sources of nearly all the large rivers of Europe, except the Danube, are on the slopes of this divide.

52. **In Asia,** the slopes of the Stanovoy and the Himalaya mountains form the chief watersheds. These mountains enclose a depression of land dotted with steppe lakes, from which the rainfall is almost wholly removed by evaporation.

53. The eastern and the southern surface slope to the Pacific and Indian oceans respectively. These slopes are drained by large rivers, the principal of which are the Amoor, Hoang, Yang-tse, Irrawaddy, Brahmapootra, Cambodia, and Ganges.

54. The Amoor river and its basin are of great importance to Russia. The valley of the Amoor is fertile, producing large crops of grain. The river is the only great inland highway in eastern Russia. It is navigable for 1,500 miles.

THE DELTA OF THE GANGES

55. The Yang-tse Kiang[1] is also an important inland highway of eastern Asia. It is navigable for large ships 250 miles from its mouth, and for river steamers, 450 miles farther.

56. The Ganges is navigable for a distance of 1,500 miles from its delta, and a greater number of vessels ply on its waters than on any other river in the world. It discharges its waters through a great net-work of channels, on one of which, the Hoogly river, Calcutta is situated. The land about the delta of the Ganges is low and swampy; it is called the Sunderbunds.[2]

[1] *Ho* and *Kiang* mean river.

[2] The Ganges is the sacred river of India, and is one of the most celebrated in the world. For fertility and richness, the valley of the Ganges has but few, if any, equals in the world.

57. **Economy of Rivers.**—Rivers are free and natural highways, and as such, their importance cannot be over estimated. Without a navigable river, the settlement of a country is usually slow and restricted.

58. In the growth and settlement of the United States, rivers have always constituted the pioneer transportation lines, and have played a most important part in the prosperity of the country. Therefore, the Government has wisely forbidden the obstruction of navigable channels, and their control is placed wholly in the power of Congress.[1]

## WHAT HAS BEEN TAUGHT IN CHAPTER XI.

***One-third of the water falling upon the Earth finds its way back to the ocean.***

***This water collects in channels, called, according to their size, rills, rivulets, brooks, creeks, and rivers.***

***In the upper course of a river, the current is rapid, always cutting and wearing its channel deeper.***

***In the middle course, it carries much of the lighter sediment taken from the upper portion.***

***In the lower course, the river deposits the sediment, building its banks and bed, often extending them some distance into the sea.***

***The sediment-carrying power of a river depends wholly upon the velocity of its current.***

***In the upper and the middle course, a river changes its channel but slightly, while in the lower part, it flows around the obstacles it has deposited in its own way.***

***A river system consists of a river and its branches; and a river-basin, the surface drained by the river system.***

***The rim of the basin forms a watershed or divide.***

***The principal divide of North America is that from whose slopes the Athabasca, the Saskatchewan, the Columbia, and the Missouri river radiate.***

***South America possesses but few well-defined drainage basins, its main watershed being the Andes mountains.***

***The chief drainage basins of Africa are those of the Nile, Livingstone, Niger, and Zambeze rivers.***

***The chief watersheds of Asia are the Himalaya and the Stanovoy mountains, from whose outer slopes the rivers flow in every direction.***

***The chief watersheds of Europe are the Valdai Hills and the Alps; the largest basins, those whose rivers flow into the Caspian and Black seas.***

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[1] **To the Teacher.**—In the study of hydrographic basins, the following exercise will be found an excellent one:—

On a good map of the United States draw a very light pencil line which shall separate the Mississippi and its tributaries from those rivers flowing into any other water than the Gulf of Mexico. This line may enclose all rivers east of the Rocky mountains, and all west of the Appalachian divide. In the same manner, the chief hydrographic basins of South America may be defined. In separating the basin of the Orinoco from that of the Amazon, it must be remembered that the Cassiquiare river divides or forks, sending part of its waters into the Orinoco, and part into the Rio Negro, a tributary of the Amazon. On the map of Europe, from the Valdai Hills draw a line which shall separate the rivers flowing into the Arctic ocean, the Baltic and North seas from those that flow into the Mediterranean, Caspian, and Black seas. This line, which should terminate at the strait of Gibraltar, is the principal divide between high and low Europe. These lines, after being inspected and corrected by the teacher, may be drawn with *red* ink.

The formation of terraces along river valleys suggests that there have been occasional periods of rest in the elevation of continents. "I counted to-day forty-one distinct ledges or shelves of terrace embraced between our water-line and the syenitic ridges through which Mary river forces itself. These shelves, though sometimes merged into each other, presented distinct and recognizable embankments or escarps of elevation. This imposing series of ledges carried you in forty-one gigantic steps to an elevation of 480 feet; and as the first rudiments of these ancient beaches left the granite which had once formed the barrier sea-coast, you could trace the passing from Drift-strewn, rocky barricades to clearly-defined and gracefully curved shelves of shingle and pebbles. The studies of these terraced beaches at various points on the northern coast of Greenland are more imposing and on a larger scale than those usually regarded by geologists as indicative of secular uplift of coast."—*Kane's Arctic Explorations.*

# CHAPTER XII.

## AVALANCHES, GLACIERS, AND ICEBERGS.

An Avalanche in the Rocky Mountains.

1. **Accumulation of Snow.**—More snow falls between the heights of 6,000 and 9,000 feet than at any other elevations. Below 4,000 feet, but little snow accumulates, and only a very small amount falls above an elevation of 11,000 feet.[1]

2. **On the Alps,** the yearly snow-fall is about sixty feet in depth. In the Cascade mountains of North America, the snow-fall considerably exceeds this amount, the snow often *accumulating* to a depth of sixty feet.

3. **Removal of the Snow.**—Except on the highest mountain-peaks, the snow is removed by the summer's heat, but in high latitudes, there are large areas of mountain territory perpetually covered with snow. In the latter case, it might seem as though the mountains would be covered deeper and deeper, until they formed an immense snow-bank many times larger than the mountain itself; but there are several agents in nature that combine to prevent this.

4. The **great weight** of a snow-drift is often sufficient to melt it at the bottom, thus preventing further accumulation.

5. **Evaporation** is another agent. Without melting, snow and ice evaporate just as certainly as water does, only not so rapidly. On the tops of mountains where the air does not press so heavily, evaporation goes on much more rapidly than at the sea-level.

6. Wet clothes hanging out-of-doors soon dry, although they may be frozen stiff. Muddy roads that have frozen over, often become dry and dusty without thawing.

7. **The wind** is another agent. On high mountain crags, the wind often blows with a velocity of 100 miles an hour. Such a gale quickly clears the snow from all exposed places, drifting and packing it solid in the ravines and cañons.

8. The larger part of the snow and ice is carried down the mountain side in the form of avalanches or glaciers.

9. **Avalanches.**—On account of their position in the center of a thickly populated district, more is known about the avalanches and glaciers of the Alps than those of any other region in the world.

[1] In the Frigid and Torrid zones, however, the case is different. In the Torrid zone, the limit of perpetual snow is about 16,000 feet above the sea-level. In the Frigid zone, the limit of perpetual snow descends to the level of the ocean.

10. **The Alpine peaks**, having abrupt slopes, are favorable for the occurrence of avalanches. When the mass of snow becomes so great that it can no longer rest on the steep slopes of the mountain, there is a sharp crack; a cleft in the snow-field appears, and then an immense mass of snow dashes down the slope with terrific violence.[1]

11. The instant the avalanche stops, the flakes of snow are changed by the great pressure to granules of ice. These quickly cohere, and the whole mass of moving snow becomes instantly as solid as ice.

12. Avalanches in the Alps occur with great frequency. Often, during a single day, a dozen or more will dash with a low, sullen roar down the mountain-side, sometimes burying villages and bearing fearful destruction in their course.[2] They are less prevalent in the Rocky and Sierra Nevada mountains, because the slopes of the latter are less abrupt than those of the Alps.

13. **Glaciers.**—The snow which has tumbled down the mountain-side in the form of avalanches and much that has fallen in a natural manner is removed in a singular way.

14. **Winds gradually drift the snow** into ravines and mountain-valleys. From these, it often extends into the region of cultivated fields and far below the altitude which marks the limit of perpetual snow.

15. If we examine this mass of snow and ice, we shall find that it is moving slowly down the ravine—sometimes not more than a few inches a month, but often twenty or thirty inches a day.

16. This moving mass of snow and ice is a glacier. Its current, resembling that of a river, is swiftest at the surface and slowest at the sides and bottom. The velocity of a glacier depends on the temperature of the ice, the steepness of the slope, and also the depth of the ice. Twelve or fifteen inches a day is an average rate.

17. The upper part of the glacier consists of snow sometimes more or less compact, but often as soft and flaky as when it fell from the clouds.

18. Very soon after it begins its journey, the alternate thawing and freezing change the snow-flakes to small rounded grains of ice, called nèvè (*nāvā*). In time, much of the nèvè,

[1] In these mountains, the greatest accumulation of snow takes place at an elevation of eight or nine thousand feet, the peaks which extend above this height being quite bare.

[2] "Having crossed about three quarters the breadth of the couloir, the leading men sunk considerably above their waists. * * * I tried to follow Bennen, but sank up to my waist. So I went through the furrow, holding my arms close to my body so as not to touch the sides. As the snow was good on the other side, we came to the false conclusion that the snow was accidentally softer there than elsewhere. Boisonnet made a few steps in advance, when we heard a deep cutting sound. The snow-field had split in two about fourteen or fifteen feet above us. The cleft was at first quite narrow, not more than an inch broad. An awful silence ensued: it lasted but a few seconds, and then it was broken by Bennen's voice, '*Wir sind alle verloren.*' (We are all lost.) They were his last words. * * * The ground on which we stood began to move slowly. I soon sank to my shoulders and began descending backwards. The speed of the avalanche increased rapidly, and before long I was covered up with snow. I was suffocating, when with a jerk I suddenly came to the surface again. It was the most awful sight I ever witnessed. Around me, I heard the horrid hissing of the snow, and far before me the thundering of the foremost part of the avalanche. At last, I noticed that I was moving more slowly: then I saw the pieces of snow in front of me stop, and I heard, on a large scale, the same creaking sound that is produced when a heavy cart passes over hard frozen snow. I felt that I had stopped, and threw up my hands to protect my head. * * * but was covered up with the snow coming behind me. I made vain efforts to extricate my arms, but found it impossible. * * * A sudden exclamation of surprise! Rebot had seen my hands. * * * I was at length taken out: the snow had to be cut with an axe down to my feet before I could be pulled out."—TYNDALL.

by the constant pressure of its particles, loses the air it had contained and becomes welded into solid ice.

19. **Crevasses.** — Numerous fissures, called crevasses, are formed in a glacier by irregularities in its course, in the inclination of its bed, and in the velocity with which it moves.[1]

20. **Moraines.** — Rocks which have been broken from the cliffs, together with stones, gravel, and other materials which have rolled, or fallen, upon the glacier are carried along with it. Such accumulations are called *moraines.*

21. Those which are at the sides of the glacier are called *lateral moraines.* Viewed from the glacier, they resemble long walls. When two glaciers enter the same valley, their moraines which meet and are carried thence along, or near, the center of the main glacier, form a *medial moraine.*

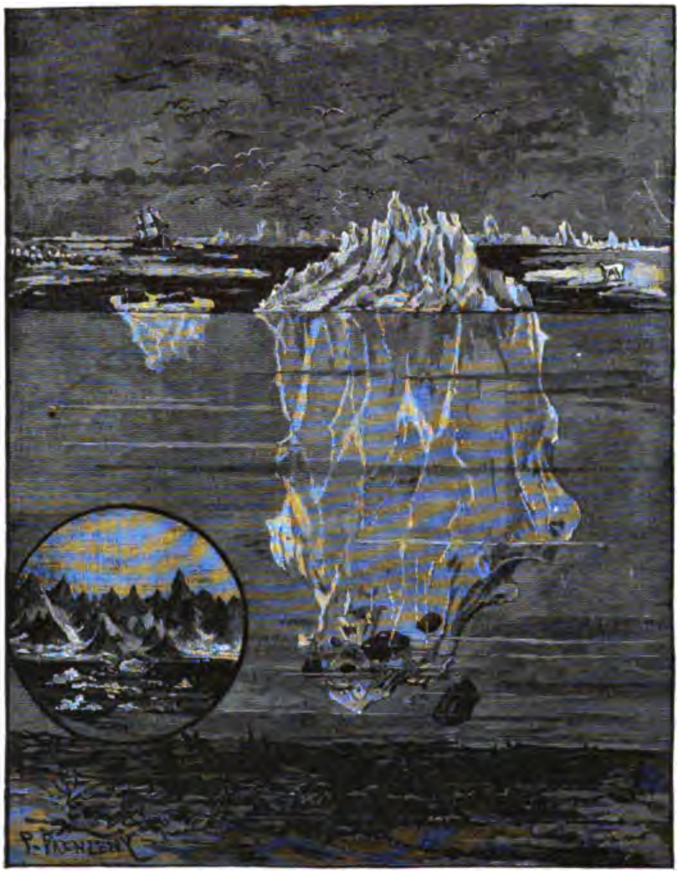
22. The great mass of stones, gravel, and other materials which have been deposited at the end of a glacier, is called a *terminal moraine.* It sometimes covers an area of more than a square mile and exceeds a hundred feet in height.

23. A river issues from the lower end of a glacier. The Rhine, Rhone, Po, and a number of the tributaries of the Danube have their sources among the Alpine glaciers.[2]

An Alpine Glacier. The beginning of a river.

[1] *The velocity* with which a glacier moves is greater in the center than at the sides, and at the surface than at the bottom. It is greater in summer than in winter, and in mid-day than at night. The greater the slope of the bed, the greater is the velocity.

[2] *The glaciers of the Alps* have their sources far above the snow-line, while their terminal moraines are about 5,000 feet below it. The snow-line on the Alps is about 9,000 feet above the level of the sea. For the formation of glaciers, it is necessary that the mountains extend above the snow-line, and that there be alternate freezings and thawings.



Floating Iceberg.

24. The water issuing from the lower end of a glacier is always muddy, because it contains substances that are worn from the bottom and the banks of the ravine.

25. **Distribution.**—There are many large glaciers in the Himalaya mountains, but they are comparatively unknown. The glaciers of Mts. Rainier and Shasta in the United States are equal in size to the largest Alpine glaciers.

26. By far the largest **glaciers** in the world are those of Greenland and Alaska. Humboldt glacier in Greenland is said to be sixty miles in breadth.

27. **Icebergs.**—Icebergs are masses of ice broken from glaciers, where the latter terminate on a sea-coast. The end of the glacier is pushed into the water until a large mass is broken off.

28. **The mass of ice** thus broken off floats along with some ocean current, until it is melted by the warmer water into which it floats.

29. **Icebergs** from the Greenland glaciers drift southward in the Arctic current, through Baffin Bay. Near Newfoundland, they meet the warm water of the Gulf Stream and drift between the opposing currents until they are melted.

30. It is thought by many geographers that the banks or shallows east of the gulf of St. Lawrence have been formed by the sand, gravel, and boulders, carried there by means of icebergs which, on melting, drop their load to the bottom of the sea.

31. **From an eighth** to a tenth of the iceberg is above water, the remainder being below the surface. On one or two occasions, icebergs projecting a thousand feet above water, have been observed; but ordinarily, they seldom exceed one or two hundred feet in height above the surface.

32. **Ancient Glaciation.**—The transporting power of glaciers is wonderful. A wide stretch of country between the Baltic and the Black sea is covered with boulders and drift, carried from the Scandinavian mountains by glaciers of a former geological period.

33. Portions of England and Scotland are also covered with similar drift, called "till." These boulders are distinguished by their faces, which are ground flat and scored with parallel scratches.

34. In examining that part of Europe which comprises the **Scandinavian peninsula, Great Britain**, and **Ireland**, one cannot help noticing the frayed and ragged appearance of their western coasts.

35. These notches in the coast are the work of glaciers which, originating in the higher portions of the Scandinavian mountains, furrowed and scraped the surface of northwestern Europe into its present shape.

36. **In North America**, the work of glaciers has been of even greater magnitude. Here, the ice-flood came from the north and extended as far south as the Ohio river.

37. The peculiar shape of most of the older North American lakes is, by many geologists, attributed to glacial action.

38. Observe that those of the northern and northeastern part, especially, are long and very narrow. Their lines of greatest length are usually parallel; but occasionally, a group of lakes, like those of central New York, are ranged like the spokes of a wheel and point to a common center.

39. Late researches have shown that lakes occur chiefly in regions covered with glacial boulders, and that they are comparatively rare in those parts of the Earth that are free from glacial action.

## WHAT HAS BEEN TAUGHT IN CHAPTER XII.

***The greatest amount of snow falls between the altitudes of 6,000 and 9,000 feet; little falls above the latter altitude.***

***This accumulation of snow is removed by wind, avalanches, glaciers, evaporation, and by melting.***

***On account of the abrupt slopes of the mountains, avalanches are most frequent in the Alps, and they usually take place just after heavy snow-storms.***

***The snow brought down the mountain side by avalanches and drifted into the cañons by the wind, forms glaciers.***

***The motion of a glacier resembles that of a river, being greatest at the center of its upper surface and slowest at the bottom and the sides.***

***The source of a glacier is fine snow, called neve, which is converted by pressure into ice.***

***The glacier, in its central and lower parts, is seamed with crevasses, extending partly or wholly across it.***

***The rocks, gravel, and earth which are piled up at the sides of the glacier, or perhaps pushed along before it, constitute its moraines.***

***The lower end of a glacier usually forms the source of a river. Most of the rivers of central Europe and many of those in Asia originate in this manner.***

***Glaciers occur in the Himalaya, the Rocky, and many other mountain-ranges, the largest in the world being those of Greenland and Alaska.***

***Icebergs are masses of ice broken from glaciers which terminate on the shores of polar regions.***

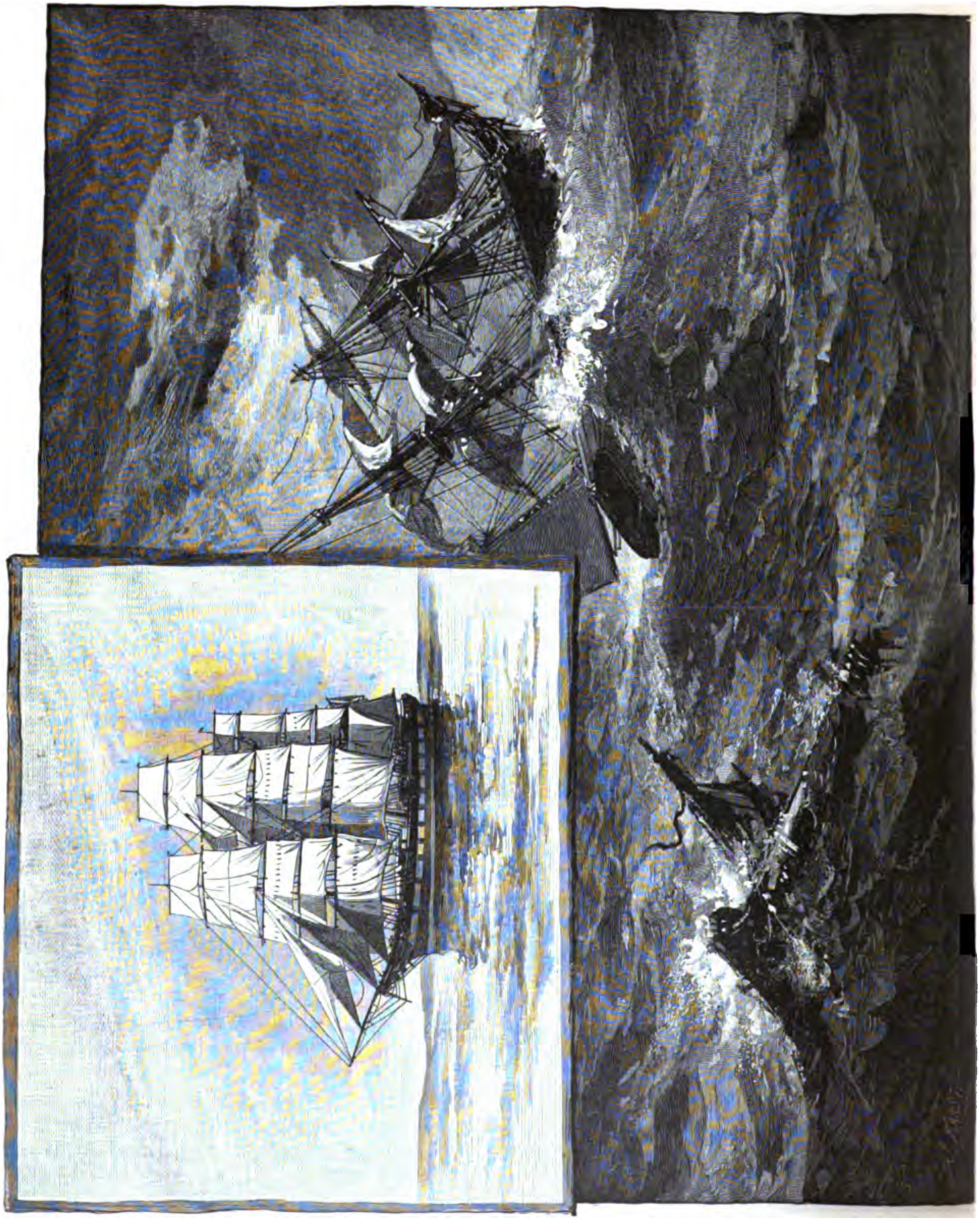
***The icebergs, broken from glaciers of Greenland, drift southward with the Arctic current until they meet the warm waters of the Gulf Stream.***

***Various parts of the world are strewn with boulders, left by glaciers during past geological ages.***

***The configuration of northwestern Europe, as well as its notched and ragged coast lines, are due to glacial action.***

***In North America, there are evidences of glacial action as far south as the Ohio river.***

***The lakes of the northern part of North America are often attributed to glacial action.***



A Calm. THE OCEAN. A Storm.

# CHAPTER XIII.

## OCEAN WATERS.

1. **Area and Extent.**—Of the 144,000,000 square miles of the Earth's crust covered by water, three-fifths lie south of the equator, and the remainder north of it.

2. Included in this area, are two million square miles about the North Pole and eight million square miles at the South Pole, concerning which little is known. It cannot be told whether these desolate fields of ice rest upon land above the ocean level or not.

3. **Divisions.**—The water surface of the Earth is divided into five great oceans called the Pacific, Atlantic, Indian, Antarctic, and Arctic oceans; their areas are as follows:

| | | | | | |
|---|---|---|---|---|---|
| **Pacific** | about 70,000,000 square miles. | **Antarctic** | about 8,000,000 square miles. |
| **Atlantic** | " 35,000,000 " | **Arctic** | " 2,000,000 " |
| **Indian** | " 28,000,000 " | **Inland Seas** | " 1,000,000 " |

4. These divisions are all parts of one great ocean. There are no boundaries separating one from another, and excepting the Arctic ocean, not one of them is landlocked.

5. **The Pacific ocean** has the shape of an oval, bounded on the south by the ice fields of the South Frigid zone. Its eastern shore forms a long and almost unbroken line. It encloses the submarine plateau of Oceanica.

6. **The Atlantic ocean** is a wide channel between the eastern and western continents. Its two shore lines are nearly parallel, the projections of one lying opposite to the indentations of the other. The shores of the northern part are noted for their many inlets.

7. **The Indian ocean** is an immense gulf, partly enclosed by Africa, Asia, and Australia. Its shore line is broken by a number of important peninsulas.

8. **Color of Ocean Waters.**—The color of the ocean varies in different places. Water more than sixty fathoms deep is blue; shallower water is generally green. The amount of mineral salts also affects the color of ocean waters. Fresher waters are a pale green, while those containing a greater proportion of salt are dark blue.[1]

9. In warm latitudes, the ocean waters sometimes glow with a pale light, such as is noticed when matches are rubbed in the dark, with moistened fingers. This phenomenon, known as *phosphorescence*, is caused by various minute animalcules.

10. The Antarctic and Arctic oceans are comparatively unknown regions, being almost covered with ice. In each of these oceans, ice forms to an average depth of seven feet during the winter. This amount is about what the sun is capable of melting during the summer. There are, however, millions of square miles covered with ice which never melts.[2]

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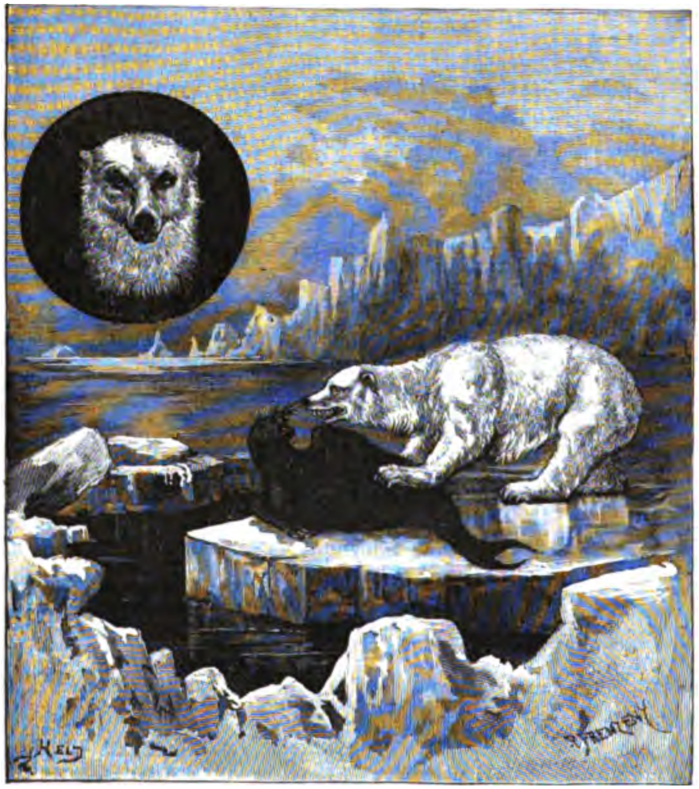
[1] The Red sea, the Arabian sea, and the Gulf of California are tinged with red; the waters of the Persian Gulf are now and then of a greenish hue; while occasionally there are, especially in the Indian ocean, great bodies of water having a milk-white appearance. These colors are due to the presence of animalcules, or else to microscopic sea weeds.

[2] Late researches render it probable that the ice caps at the poles have formed upon *islands*, gradually spreading until a continuous sheet of ice of unknown thickness has accumulated.

11. **The Bed of the Ocean.**—The bed of the ocean consists of extensive plains and plateaus. Wherever submarine mountain chains occur, they are near some continental coast. The shores and nearly all shoals are usually strewn with fine sand.

12. **Temperature.**—The temperature of the ocean varies both with latitude and depth. Within the tropics, the surface temperature is about 80° F. In the polar regions, it does not vary much from 28° F.

13. Below the depth of 600 feet, the temperature is not affected by the heat of the sun: and except where influenced by warm ocean currents, it decreases uniformly to 35° F., from which it varies but two or three degrees.



The Frozen Zone.

14. Where the bed of the ocean is not affected by waves or currents, it is covered with ooze, a substance consisting of the shells, skeletons, and the insoluble parts of minute sea organisms. The ooze covers the bed of the ocean in many places to a great depth.

15. **Mineral Salts.**—Ocean waters contain an average of 3.4 per cent. of mineral substances, of which common salt is the chief. The following table shows the composition of the mineral salts in every 1,000 parts of sea water.

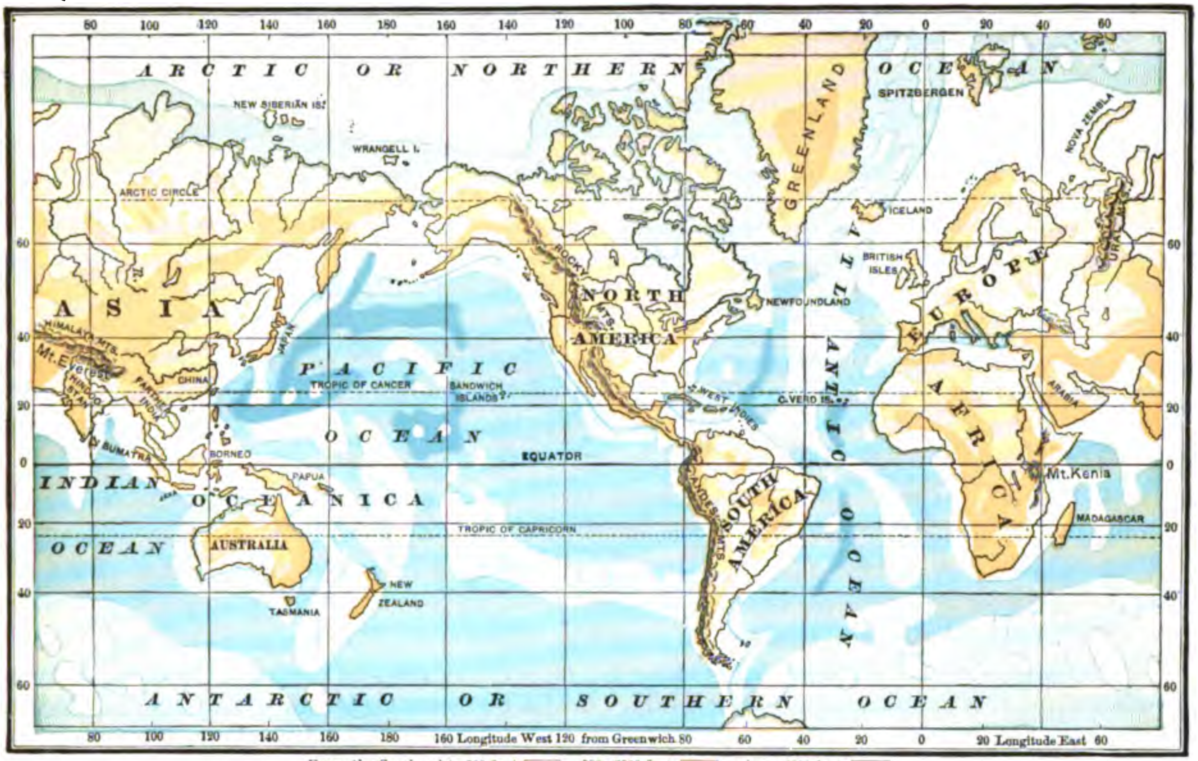
| | |
|---|---|
| Sodium chloride (Salt) | 27.0 |
| Potassium and Magnesium chlorides | 5.8 |
| Magnesium and Lime sulphates | 2.1 |
| Lime carbonate | .1 |
| Iodine, Bromine, and other substances | 3.0 |

16. **The percentage of mineral salts** varies in different localities. In parts of the Arctic ocean, the salt is almost imperceptible. In the Baltic sea, the water contains but two per cent., while in the Red Sea, which lies under a tropical sun, there are 4.3 parts of salt in every 100 of water.

17. Additional supplies of mineral salts are constantly conveyed by the waters of rivers which, flowing into the sea, deposit there the mineral salts which they have dissolved from the soil. These salts, therefore, accumulate in the ocean, and mostly remain dissolved. The carbonate of lime, however, is appropriated about as rapidly as it is supplied, by shell-fish and other sea animals whose skeletons are composed of that substance.[1]

[1] The chalk cliffs of England, much of the limestone of the Mississippi valley, and the coral reefs, have all been formed in this manner. Fresh river waters contain salt and carbonate of lime in about equal proportions. In ocean waters, however, there are 270 parts of salt to 1 part of carbonate of lime.

CONTOUR MAP, SHOWING PROPORTIONATE HEIGHTS OF LAND AND DEPTHS OF WATER.




From the Sea-level to 500 feet 500—2000 feet above 2000 feet
Depth in fathoms: under 1000 1000—2000 2000—3000 3000 and below

18. **Depth.**—The average depth of the ocean is about 16,000 feet. Whenever deeper soundings are met with, the area over which they extend is not a large one; and except along the shores of continents, the variations in depth are slight.[1]

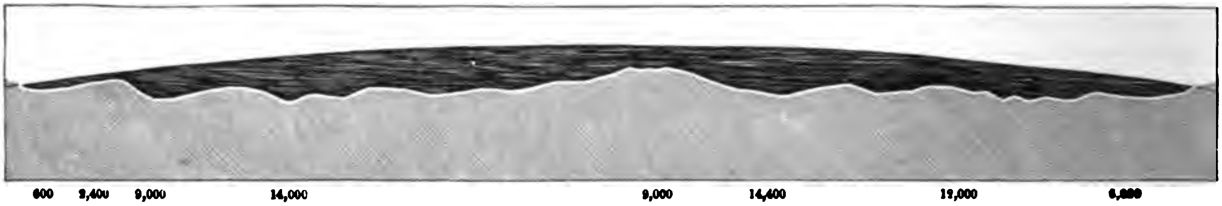
19. **The depth of the Atlantic** varies in different parts; near the western side it is 19,000 feet. Between the two continents, there is a well-defined, submarine highland known as the "telegraphic plateau," on which the water is about 10,000 feet deep.[2]

20. **Along the American coast,** the bed of the Atlantic consists of several well-defined terraces. The first of these is about 100 miles in width, having an average depth of less than 1,000 feet. At the edge of the terrace, the bed descends almost precipitously to a depth of 9,000 feet. It then gradually descends to about 16,000 feet.

21. **The depth of the Pacific** and Indian oceans is the same as that of the Atlantic —16,000 feet. The soundings made in the Arctic ocean indicate a very slight depth; those of the Antarctic are much greater.

[1] By measuring the breadth, height, and velocity of waves, mathematicians are able to determine the average depth of the ocean. In late years, the soundings made with steel wire confirm the calculated depths.

[2] This plateau extends from the Azores to Iceland, and divides the bed of the north Atlantic into two valleys. The depth of water on the plateau nowhere exceeds 12,000 feet, and is generally about 9,000 feet. The depth of the eastern valley varies from 12,000 to 15,000 feet, and has been traced as far south as the Cape of Good Hope. The western valley has a more uneven surface and contains a greater depth of water.



Section of the Atlantic Ocean between Newfoundland and Ireland. The figures show the depth in feet.

22. **Inland seas** and land-locked waters are always shallow. The Gulf of Mexico and the Mediterranean sea vary in depth from 7,000 to 10,000 feet. The Red Sea is about 3,000 feet deep; the Baltic and North seas, about 600 feet. The depth of Bering Strait does not exceed 150 feet.

23. **The deepest soundings** have been made off the eastern coasts of the continents. East of the Kurile islands, a sounding of 27,930 feet, and southeast of Newfoundland, one of 27,480 feet, have been recorded. Deeper soundings than these have been reported, but they are not considered trustworthy.[1]

24. **Waves.**—The surface of the ocean is never at rest. Even when it is not lashed into billows by the wind, it is constantly heaving in long, gentle swells.

25. Waves are caused usually by the wind. They consist of the alternate rising and falling of successive ridges of water. In deep water, although the wave moves forward, the water does not; its only motion is the rising and falling.

26. This is apparent when the wind blows over a field of grain. Each stalk bends before the gust, but immediately straightens, while an instant later, the grain just ahead bends and straightens. Thus the *wave* passes over the field.

27. **In shallow water,** however, the motion of the wave at its lower part is retarded by friction against the bottom. This causes the top of the wave to comb or roll forward and break into foam.


Storm Waves.

28. **The size** of a wave depends somewhat on the depth of the water. No large waves form in water less than 200 feet deep.

29. **In deep seas,** during a fair breeze, the waves are about six feet in height from trough to crest, and sixty in breadth. Waves of this size have an average velocity of nine miles an hour; during a severe gale, the velocity of waves sometimes exceeds twenty-five miles per hour.

30. During a severe gale, the top of a wave moves faster than its lower part. In consequence, the waves break and the sea is covered with white-caps, or, in very severe storms, is lashed into foam.

[1] These soundings are as reported by Commodore George E. Belknap, when commander of the United States steamer "Tuscarora." Prior to the adoption of steel wire, rope was used for deep sea soundings. Soundings made in this manner are now considered wholly untrustworthy. By the late methods, not only are specimens of the bottom secured, but the temperature at any depth may also be registered.

31. The waves do not reach their greatest height until the storm lulls. In deep water, waves of forty, fifty, and even sixty feet in height have been observed. The breadth of such large waves sometimes exceeds four hundred feet.

32. **Force of Waves.**—The force with which waves beat against the shore is almost beyond belief. A wave moving with ordinary velocity strikes a blow of 610 pounds per square foot; but in severe storms, the striking force often exceeds 6,000 pounds upon every square foot of surface.

33. The lighthouse on Minot's ledge, near Boston, has been thrice destroyed by storms, the last time, in 1857. Although it was built of solid iron piles *ten inches in diameter*, the combined force of wind and wave swept it away. Not a vestige of the structure has ever been found.

34. The form of the New England coast is very largely the work of waves. These wear away the softer rock and the tides carry off the *dèbris*. The reefs and rocky islands along the shores are the remnants of former coast lines.

## WHAT HAS BEEN TAUGHT IN CHAPTER XIII.

*Three-fifths of the ocean waters lie south, and the remainder north of the Equator.*

*It is not definitely known whether the regions about the poles are land, or water, chiefly.*

*The Pacific is the largest ocean, being about twice the size of the Atlantic, and nearly as large as the remaining four divisions together.*

*In the Arctic ocean, ice forms to an average thickness of seven feet during the winter, and much of this ice remains throughout the year.*

*The bed of the ocean is diversified with plateaus and plains.*

*The best known submarine plateau is in the Atlantic ocean, midway between the eastern and western continents.*

*The average depth of the larger oceans is about 16,000 feet, or three miles.*

*The depth of land-locked oceans and inland seas is never great, and seldom exceeds 3,000 feet.*

*The water of the ocean contains various mineral salts in solution, the principal of which is common salt.*

*The amount of salt varies from two-tenths per cent. in the polar oceans to four and three-tenths per cent. in the Red Sea.*

*The surface of the ocean is never at rest, but is constantly tossed with waves or gentle swells.*

*Waves are the alternate rising and falling of successive ridges of water upon the surface of the sea.*

*The wave has a progressive motion, but the water has not.*

*The height of the wave, usually about one-tenth its breadth, depends chiefly on the depth of water.*

*With a fair breeze, deep water waves are about sixty feet broad and six feet high. Their velocity is eight or nine miles per hour.*

*The velocity of storm waves sometimes exceeds twenty miles an hour.*

*The breaking of waves occurs wherever the crest of the wave moves faster than the lower part.*

*The waves run highest at the lulling of the storm. Then they are sometimes sixty feet in height and four or five hundred feet in breadth.*

*The force with which a wave strikes varies from 600 pounds to the square foot in ordinary weather, to 6,000 pounds to the square foot during severe storms.*

# CHAPTER XIV.

## TIDES.

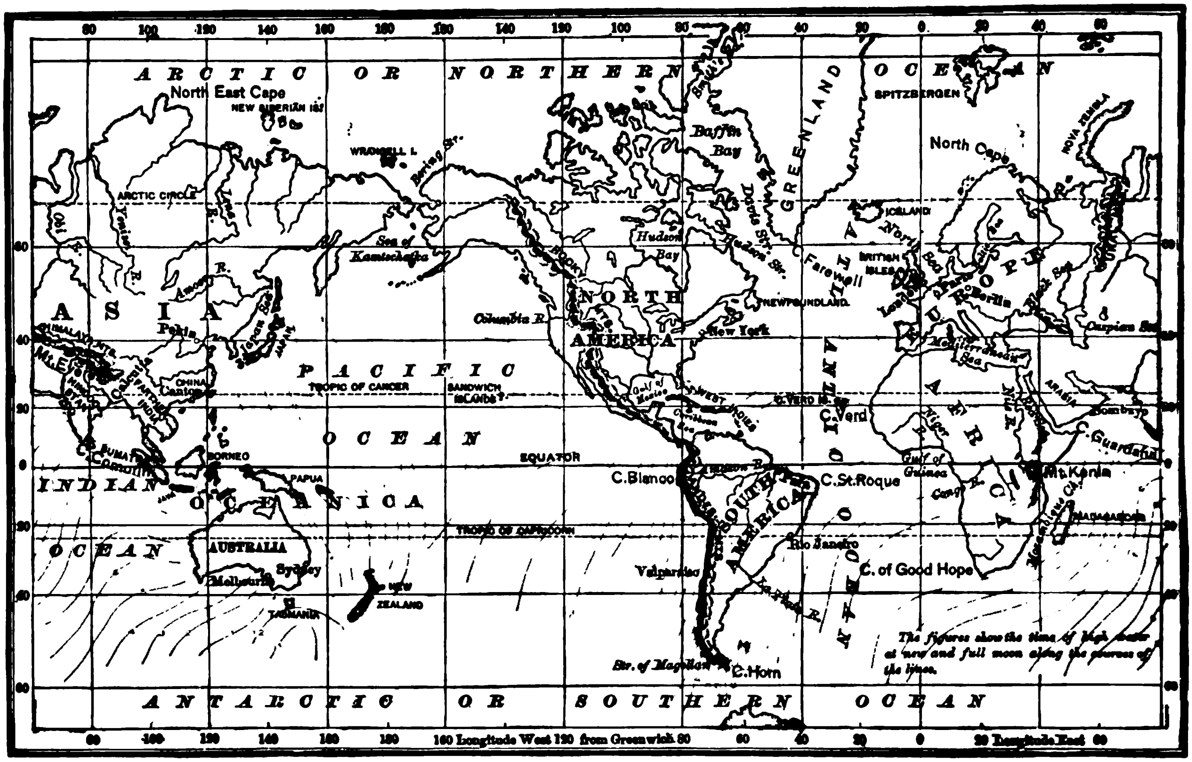



CHART OF CO-TIDAL LINES.

The blue lines in the Chart show the position and the direction of the crest of the tide-wave for each hour of the day. It is seen that the direction of the theoretical wave exists only in the broadest expansion of the ocean.

1. **Movements of Ocean Waters.**—There are two movements of ocean waters which are regular and constant; they are tides and ocean currents.

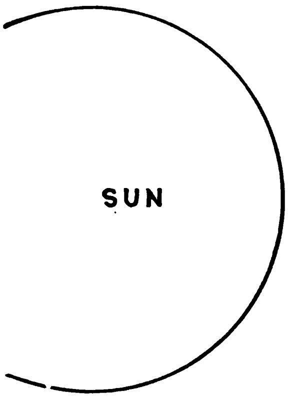
2. **Tides** are immense waves which, in mid-ocean, are about three feet in height and several thousand miles in breadth.

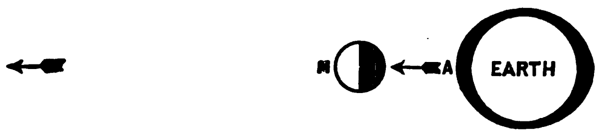
3. **An observer** standing on the sea shore, will notice that the level of the water is not always the same. For six hours, it reaches higher and higher upon the beach. Then it ceases to rise; and after a few moments, begins to recede. It continues to fall for six hours, when the waters, after remaining stationary for a few moments, again begin to rise.[1]

[1] The rising of the water is called the "flood," and the falling, the "ebb" of the tide. The periods of greatest elevation and depression are known as "high water" and "low water," respectively; that of the cessation of the current, "slack water."

4. **The cause** of this rising and falling of water is ascribed to the attraction which the sun and moon exert upon the waters of the Earth.

5. **Gravitation.**—Both the sun and the moon attract the Earth. But while the crust of the Earth, being rigid, does not noticeably bend, the water is drawn in an elongated or lemon-shaped form, on account of which it appears to be massed toward the attracting bodies, as you see in the diagram below.



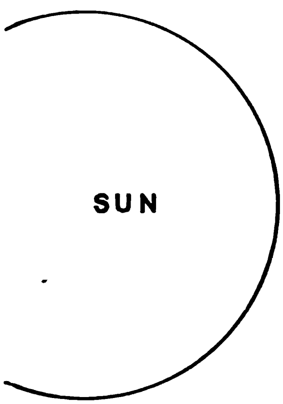

Moon in Conjunction, or between the Earth and Sun.

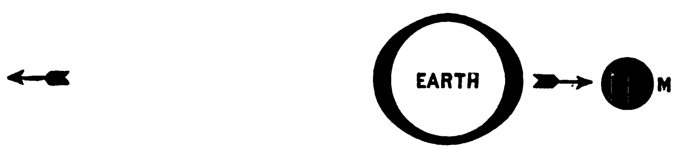
6. High water does not occur when the moon is directly overhead, but several hours afterward. In other words, the tide-waves, owing to friction against the bottom of the ocean, cannot quite keep pace with the moon, and therefore lag behind.

7. The tide-waves are highest in the tropics, and, except where the shores of continents cause local irregularities, their height diminishes in the direction of the poles.

8. Not only is the water drawn into an ovoid form, but the Earth, also, is pulled towards the moon. This, in effect, gives the appearance of two waves, one on each side of the Earth.[1]

9. **Moon in Conjunction.**—When the sun and moon have the relative position shown in the accompanying diagram, it is evident that their combined attraction will produce a tide-wave, having a much greater height than the attraction of either body alone. In this position, the moon is said to be in *conjunction.*



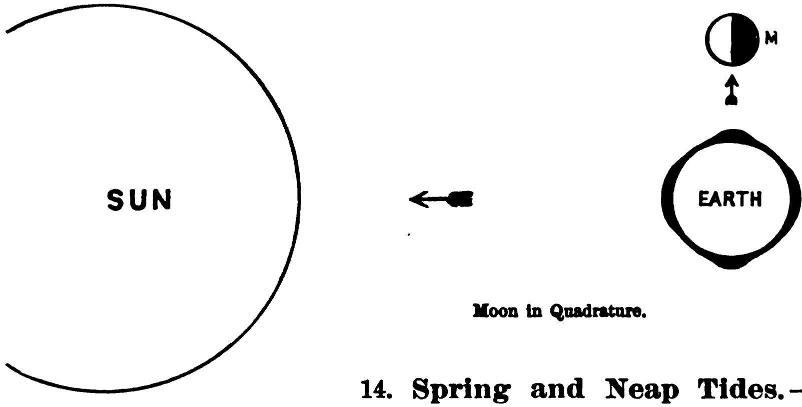

Moon in Opposition, or on the side of the Earth furthest from the Sun.

10. **Moon in Opposition.**—Even though the sun and the moon are on *opposite* sides of the Earth, their combined attraction being in the same line, forms a tide-wave as high as though both were on the same side. When the moon is on the side of the Earth furthest from the sun, as you see in the diagram, it is said to be in *opposition.*

[1] This theory of the formation of the tide-wave on the opposite side of the Earth is not accepted by all scholars.

11. **Moon in Quadrature.**—But if the moon is in the position shown in the following diagram, the sun and the moon exert their attractive force, each in a different direction. In this position, the moon is said to be in quadrature.

12. **Four tide-waves a day** will take place at such times—two formed by the sun, so slight as to be hardly noticeable, and two by the moon, each of which is smaller than when both the sun and the moon exert a combined attraction.




Moon in Quadrature.

13. The tide-wave formed by the sun, however, is a few inches only in height. In using the term "tide-wave," the wave caused by the moon is always meant.

14. **Spring and Neap Tides.**—Tides occurring at new and at full moon—or when the moon is either in opposition or in conjunction—are called *spring tides;* those occurring when the moon is in quadrature are *neap tides.*

15. **Course of the Wave.**—The two tide-waves thus formed on opposite sides of the Earth, accompany the moon and pass around the Earth, each in about twenty-eight days. But while the two waves are journeying around the Earth, the latter is turning in the same direction upon its axis every twenty-four hours.

16. Therefore, instead of two tides a month, there are two tides a day. Each day, the tide is at flood-height about fifty minutes later than on the preceding day.[1]

17. **Effect of Land Masses.**—In the foregoing description, it has been assumed that the surface of the Earth is evenly covered with water. The motion and direction of the tide-waves are greatly modified by the continents. Especially is this the case in the northern hemisphere, for here the actual tide conforms but slightly to the theoretical.

18. The tides, instead of having a uniform height of two and one-half or three feet, as in mid-ocean, are in the North Temperate zone about four feet, although they sometimes exceed sixty feet.

19. **Local High Tides.**—In the Bay of Fundy, the tide rises to a height of from fifty to eighty feet. The reason for this excessively high tide is the shape of the coast, and its position with respect to the direction of the wave.

20. By looking at the map, you will notice that the tide-wave of the northern Atlantic travels in a northerly direction. The coast of Nova Scotia and the shores of the Bay of Fundy have the shape of a $\Lambda$, which faces the south.

[1] The pupil must bear in mind that *the two tide-waves with reference to the moon are stationary*—that is, they revolve around the Earth just as though they were fastened to the moon. The daily tides are caused by the Earth turning on its axis *within* the tide-waves. Consequently, an observer *overtakes* and *passes* the two waves daily.

21. **Into this bay,** the tide-wave rushes with a terrific roar, and as the water cannot spread out, it must rise all the higher. In many estuaries, the *bore* or *egre* thus formed is a wave twenty or thirty feet in height, moving with a velocity of fifteen miles an hour.

22. All V-shaped bays and estuaries which face the tide-wave have very high tides. At the mouth of the Hoogly, one of the branches of the Ganges river, and in various inlets of the Indian Ocean, the tide often rises to a height of forty feet or more.[1]

23. **Inland** seas do not usually have a noticeable tide, though there are a few remarkable exceptions. Thus, while the tide of the Mediterranean is hardly perceptible, that of the Adriatic (*ăd-re-ăt'ic*) is between one and two feet in height. The tides of the Red Sea are often six feet in height.

24. This difference in the tide-level is especially great on the shores of the isthmus of Panama. Here, the tide of the Atlantic ocean is scarcely apparent; that of the Pacific is between twenty-five and thirty feet.

25. The erosive power of tides is very great. By their action, bays are formed, and channels are quickly cleared of the sediment and débris scoured from the coast shores.

## WHAT HAS BEEN TAUGHT IN CHAPTER XIV.

*Tides are waves about 10,000 miles in breadth, and in mid-ocean about three feet in height.*

*Two of these waves occur daily, each wave requiring about twelve hours in its rise and fall.*

*The cause of the tide-waves is thought to be the attractive force of the moon and the sun.*

*When the sun and the moon are in conjunction, or in opposition, the tides reach their height.*

*When the sun and the moon are in quadrature, there are four tide-waves a day, those caused by the sun being but slightly noticeable.*

*Each tide-wave travels around the Earth in about twenty-eight days.*

*While these waves keep pace with the moon in its revolution, the Earth turning once a day on its axis, overtakes a tide-wave about every twelve hours.*

*The tides of inland seas are generally small or else imperceptible. Those of the Red Sea are the highest.*

*High water occurs fifty minutes later on each succeeding day, because the Earth revolves in the same direction that the tide-wave travels.*

*The continents greatly modify both the direction and the height of the tide-wave.*

*In the South Pacific ocean, the tide-wave moves in its normal direction towards the west, or the northwest.*

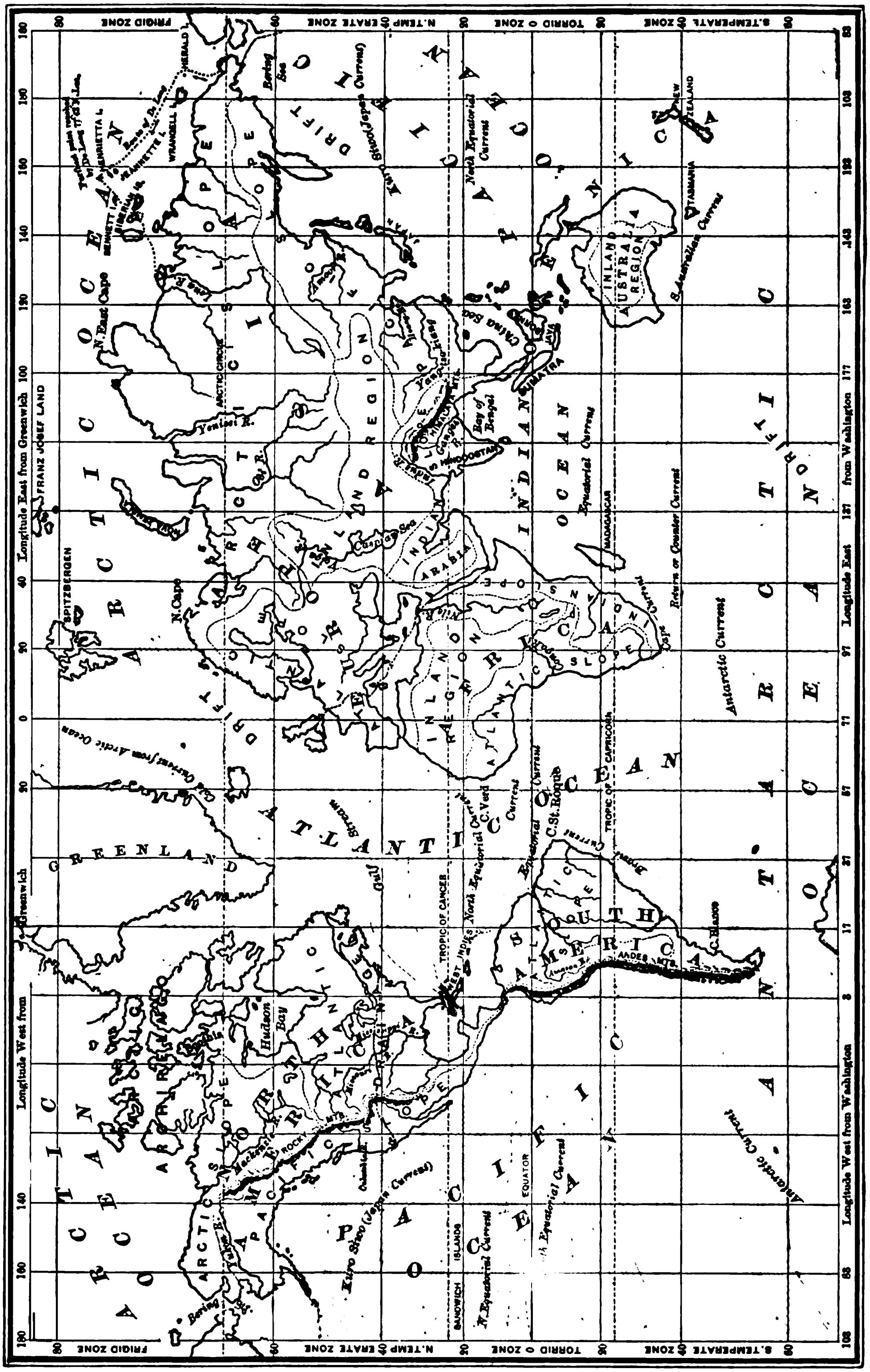
*In the northern hemisphere, the tide-waves are deflected towards the north.*

*On eastern coasts the height of the tide is usually from four to six feet.*

*In Λ-shaped estuaries which face the tide, such as the Bay of Fundy, the tide often reaches a height of fifty feet or more.*

*The highest tides are on the eastern and southeastern coasts of the continents.*

[1] The observations taken by Lt. Greely in Kane Sea and Smith Sound demonstrate that in those localities the tide-wave *comes from the north.*




## Chart of Ocean Currents.

Compiled from the U. S. and British Charts.

# CHAPTER XV.

## OCEAN CURRENTS.

In the Gulf Stream.

1. **Movements of Ocean Waters.** — There are other movements of ocean waters which are of great importance not only to mankind, but also to every form of life upon the Earth. These are currents or rivers in the ocean itself.

2. There are currents in all parts of the ocean, but they are more noticeable near the shores of continents because here their velocity is greatest. Temporary currents or movements of ocean waters caused by winds are prevalent in all parts of the ocean. These irregular movements are not constant, and therefore, are not classed among ocean currents.

3. **The temperature** of an ocean current always differs from that of the water surrounding it, and may be either warmer or colder.

4. **The color,** too, of ocean currents usually differs from that of the surrounding water. Sometimes the contrast is so great and the line between them so distinct that it seems as though a transparent partition separated them.

5. **Causes.** — Various theories have been advanced to explain the causes of ocean currents, but many of the phenomena are as yet unaccounted for.

6. Probably the prime cause is the heat of the sun. The temperature of the water in tropical regions is from 80° to 86° F., while that of the polar regions varies between 28° and 35° F. If water at 32°, which just fills a vessel, be heated to 85°, it will expand and a part of the water will run over.[1]

[1] Ocean water freezes at a temperature varying from 27° to 32° F. The temperature depends on the percentage of salt.

7. This is about what occurs in the ocean. The water in tropical regions is heated, and, increasing its bulk, flows over the surface toward the poles, while the polar waters being correspondingly heavier, flow below the surface towards the equator.

8. **As the colder water becomes warm,** it in turn rises and flows toward the poles, thus producing a circulation which never ceases.

9. There are many other causes which are powerful aids to the circulation of oceanic waters. The enormous evaporation in the Torrid zone has a tendency to increase the under-current of cold water flowing towards the equator.

10. **The vast amount of fresh water** drained from the great basins surrounding the Arctic ocean, adds another cause. This water being fresh, is, bulk for bulk, much lighter than the average ocean water.

11. **The rotation of the Earth** is likewise sufficient to cause a movement of ocean waters. Inasmuch as the general direction of the winds results from the heat of the sun and the rotation of the Earth, it seems probable that the circulation of ocean waters is governed by the same laws.[1]

12. **The unequal level** of the ocean is also an important but comparatively unknown factor in the circulation of ocean waters. Recent investigations show that at the parallels of 28°, there is an accumulation of water forty feet higher than the normal level of the sea at the poles, and about five feet higher than the actual level at the equator.

13. **The winds** have much to do with ocean currents, and they certainly give to them their direction. Indeed, there are many distinguished scholars who assert these to be the prime cause of ocean movements.[2]

14. **Classification.**—There are two general classes of ocean currents, viz.: warm currents flowing toward the poles, and cold currents flowing from the polar regions.

15. There are also several large areas within the Calms (see chart of Winds) which are not disturbed either by ocean currents or by winds. On account of the immense quantities of sea-weed which have accumulated there, they are known as Sargasso seas.[3]

16. **Direction and Velocity.**—Taking into account all causes that form or modify ocean currents, the general circulation of water is :—In equatorial regions, *a steady flow of water in a westerly direction.* In temperate latitudes, *a general movement of water to the eastward.*

17. In each case the current north of the equator has a northerly drift, and south of the equator, a southerly tendency. The average rate of these great equatorial currents is about 10 miles per day. All other currents are due to these general movements, or are closely connected with them.

18. **The Gulf Stream.**—One of the most famous, and certainly the best known ocean current, is the Gulf Stream. This current is formed by the turning of a portion of the westward equatorial current, along the northern shores of South America.

[1] The absorption of certain mineral salts, such as carbonate of lime, by corals, mollusks, and foraminifera, to a limited degree, affects the specific gravity and thus creates motion.

[2] The shores of the continents also modify greatly the direction of ocean currents.

[3] These accumulations of sea weed have been considered by many as the result of immense eddies or whirlpools, formed by ocean currents. Late researches do not strengthen this theory.

19. **In the Caribbean Sea,** it gradually turns northward, passing around and between the West Indies. A large part of this current passes through Florida Strait, where it receives a noticeable addition from the heated waters of the Gulf of Mexico.

In the Gulf Stream. A Storm Gathering.

20. **The two currents** combined have a velocity of nearly five miles an hour as they pass through Florida Strait; but to the northward, their velocity gradually decreases. Off Cape Hatteras, it seldom exceeds two miles per hour.[1]

21. Until this current is opposite Charleston, S. C., its waters reach to the bottom of the sea, flowing with such force that, in many places, the bed of the sea is swept bare.[2]

22. In most places, however, the bottom is strewn with minute shells brought from the Caribbean sea. These serve to mark with accuracy the course of the stream.

23. By the time this current has reached latitude 35°–40°, its waters have spread out like a fan. Not only does it extend northward to the northwestern shores of Europe, but it also reaches eastward to the strait of Gibraltar.

24. As a *surface* current having a definite direction, a measurable velocity, and other distinguishing features, the Gulf Stream cannot be well traced north of latitude 50°.[3]

25. **The warm waters of the Gulf Stream,** perhaps combined with those drifted from the equatorial current, are directly connected with the mild climate of northwestern and western Europe.

26. Moving in northern latitudes with an almost imperceptible motion, they give heat to the trade-winds, which, blowing over western and northwestern Europe, temper its climate, making even the northern shores of the Scandinavian peninsula far milder than the coast of Nova Scotia, many degrees southward.[4]

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[1] The Gulf Stream does not flow around the shores of the Gulf of Mexico, as has been until recently supposed; its direction in Florida Strait is to the northeast in about the same trend as the peninsula of Yucatan.

[2] About fifty miles east of Charleston, S. C., and extending north as far as Cape Fear, there is a current setting strongly to the southwest, even in the face of a hard wind. This current is much dreaded by pilots and masters of vessels. It is thought to be due to the rising of the Arctic current.

[3] "The cold current running along the east coast of Greenland is both in width and depth very insignificant, and rests *even near the shore,* upon one of warm water produced by the Gulf Stream. Davis Sound and Baffin Bay, on the other hand, are filled with cold or slightly warmed water *to the bottom.* Contrary, however, to general belief, *the west coast of Greenland is washed by cold water, while a greatly heated current of water coming from the south, runs along the east coast a distance of 40' to 50' only from the shore.*"—Baron Nordenskjold. *Report of Greenland Expedition.*

[4] The port of Hammerfest, situated within the Arctic circle, is open to navigation throughout the year.

27. **The Kuro Siwo.**—The most important current of the Pacific ocean is the Kuro Siwo or Japan current, a branch of the equatorial, flowing northward along the east coast of Asia. This current is not only a much smaller one than the Gulf Stream, but it is also a much colder current.[1]

28. In winter, when the northeast monsoons are strong, the Kuro Siwo is scarcely noticeable farther north than the southern limit of the Japan islands, and often it is arrested for days at a time by adverse winds.

29. In summer, with the coming of the southwest monsoon, the Kuro Siwo puts forth its strength and passes the northern extremity of the Japan islands before turning eastward.

30. During all seasons of the year, however, the Kuro Siwo obeys the laws of ocean currents and turns eastward, where its waters, spreading out, are pushed towards the American continent.[2]

31. **Cold Currents.**—The most important cold currents come from the Arctic ocean, one through Baffin Bay, and another to the eastward of Greenland. These unite off the extremity of Greenland, and continue as surface currents, as far south as Newfoundland.

32. The cold current east of Greenland is, according to Baron Nordenskjold, a surface current flowing on the top of a warm under current. South of Newfoundland, it becomes an under current.

33. The Arctic currents meet the Gulf Stream at the surface off the coast of Labrador. The moisture-laden atmosphere is here cooled to such an extent that dense fogs constantly hover over this region.

34. The icebergs brought down by the Arctic current, on reaching the latitude where these currents meet, drift helplessly about until they melt.[3]

35. The cold currents of the Antarctic ocean consist of a general drift of the waters towards the northeast, rather than well-defined currents.

36. **Currents of the Indian Ocean.**—The most important current of the Indian ocean is the Malabar. It is formed by the northward bending of the equatorial current. The Malabar, like the Kuro Siwo, is greatly modified by the monsoons.[4]

37. **Other Currents.**—There are several other well-defined ocean currents, especially in the southern hemisphere, of which the Brazilian and the Mozambique are perhaps the most important.

38. **Economy.**—Each of these currents, whether warm or cold, has an important influence upon that part of the continent along whose shores it flows.

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[1] In latitude 35°, the average winter temperature of its waters is 63° F.; the average summer temperature is nearly 70° F.

[2] No branch of the Kuro Siwo enters Bering Sea; on the contrary, the only current of Bering Sea is a *movement of water southward through the strait.*

[3] A cold current has been discovered by Prof. Davidson, off the coast of California, lying close to the shore. Its origin and destination are as yet unknown.

[4] There is a surface current entering, and an undercurrent flowing out of the Red Sea through the strait of Bab el Mandeb. This is said to be owing to the great evaporation going on in this body of water. The evaporation from the surface is sufficient to cause an inflow of water, while the increased specific gravity of the remaining waters, containing about one-fourth more of mineral salts, would cause an outward flow at the bottom.

39. The influence of the Gulf Stream on northern and western Europe presents a strong contrast to that of the Arctic current upon Labrador. The latter is an uninhabitable, frozen waste; the former, the center of the most thickly populated part of the world.

40. Terrific storms follow the track of all warm ocean currents. This is especially true of the region about the China Sea, and that part of the Atlantic ocean which is east and southeast of the United States.

41. The exceedingly large rainfall of the southeastern part of the United States, varying from 70 to 90 inches per year, is owing to the moisture-laden winds of the Gulf Stream.

42. Thus we may see that the ocean, which at first may appear as a great waste, is an absolute necessity to all forms of life upon the Earth. It is the source of all fresh waters; and by carrying away the intolerable heat of the tropics, it tempers alike the cold and the warm parts of the Earth.

## WHAT HAS BEEN TAUGHT IN CHAPTER XV.

***Currents of water exist in all parts of the ocean. Their temperature differs from that of the waters in which they flow. These movements are caused chiefly by the heat of the sun.***

***The water at the Equator is heated to a temperature of about 80° F., while at the polar regions, the temperature is often as low as 27° or 28° F.***

***The heating of equatorial waters increases their bulk and causes a current towards the poles.***

***These movements are balanced by cold undercurrents of water flowing from polar regions towards the Equator.***

***The direction of ocean currents is due chiefly to the winds, the shores of continents, and the rotation of the Earth on its axis.***

***The general direction of warm ocean currents is westward in the Torrid zone, and eastward in the Temperate zones.***

***Within the region of calms, there are areas of undisturbed waters filled with seaweed, which are known as Sargasso seas.***

***The direction of cold currents is irregular, but always towards the Equator.***

***The Gulf Stream, the most important branch of the equatorial current, has its origin in the Caribbean sea.***

***From the coast of Florida, it takes a northeasterly course reaching to the North sea and spreading along the shores of western Europe.***

***Its velocity along the southeastern coast of the United States varies between two and one-half and four and one-half miles per hour.***

***The Kuro Siwo, the most important current of the Pacific ocean, is a smaller and colder current than the Gulf Stream.***

***Its northern limits are controlled by the monsoon winds which often wholly check it for days at a time.***

***Its waters are finally distributed along the Pacific coast of North America, whose climate this current is thought to modify.***

***The principal current of the Indian ocean is the Malabar, a branch of the equatorial current.***

***The principal cold currents are the Arctic currents, one flowing southward through Baffin Bay, the other flowing to the eastward of Greenland.***

***A feeble cold current flows out of the Arctic ocean through Bering Sea.***

***The warm ocean currents, flowing through the colder regions of the Temperate and Frigid zones, modify their climate by warming the winds which blow over them.***

# CHAPTER XVI.

## THE ATMOSPHERE AND ITS MOVEMENTS.

1. **Density.**—The atmosphere, or air, is the outer part of the Earth which surrounds the solid crust. It is extremely light; one cubic foot weighing about one and one fifth ounces, while a cubic foot of water weighs 62.42 lbs., or about 800 times as much.

2. **Height.**—The height to which the atmosphere extends above the surface of the Earth is estimated at from 50 to 200 miles. The weight of a column of air as measured by the barometer indicates the former height.

3. The great height at which meteors are vaporized, together with the measured height of the Aurora Borealis—both of which are thought to depend upon the atmosphere—leads to the belief that it extends at least 200 miles beyond the Earth's surface.

4. **Composition.**—Air is composed of a number of gases in a state of mixture. Every 100 parts contain 77.95 of nitrogen, 20.61 of oxygen, 1.40 of aqueous vapor, and 0.04 of carbon dioxide.

The Barometer.

5. **The amount of water** varies greatly, seldom being the same on two successive days. The amount of carbon dioxide is likewise variable, being greatest in thickly populated localities.

6. There are also minute dust particles, the various vapors and gases constantly rising from the earth, the products of combustion, and occasionally, traces of meteoric dust.[1]

7. **Physical Properties.**—Air is highly elastic, a pressure of about 15 lbs. per square inch being sufficient to reduce its bulk one half. It will also expand as the pressure decreases.

8. **The Barometer.**—The pressure and the weight of the air are found by means of the barometer, which is shown in the accompanying figure.

9. The tube which is closed at one end is filled with mercury and inverted, the open end being placed in a dish of mercury. The mercury sinks in the tube until the column, if the experiment be performed at the sea-level, is about thirty inches high.

10. **The column is held** at this height by the pressure of the air on the surface of the mercury in the dish. In other words, the air and the mercury exactly balance each other, and, therefore, have each the same weight.

[1] The red sunsets of 1883–4 have been attributed to the latter cause. Certain it is that microscopic analyses of the air proved the presence of finely divided volcanic matter in great abundance. By Professor Tyndall, the blue color of the sky is attributed to the presence of minute particles held in the atmosphere.

11. **By weighing** the column of mercury, we at once know the weight of the column of air which balances it. At the sea level, when the column of mercury is thirty inches high, the weight on every square inch of surface is 14.7 lbs.

12. **Changes of Barometer.**—But the column of quicksilver in the barometer tube is constantly changing in height. Therefore, we know that the thickness and weight of the layer of air over our heads are constantly changing.

13. **If the mercury rises** to a height of 30.7 inches, it indicates that a wave of air has gathered above us; should it fall to 29.4 inches, it follows that there is a much thinner layer of air overhead.

14. Observations taken in different latitudes at the sea level show that the atmosphere does not surround the Earth in a layer of equal thickness, but is distributed, as you may see in the diagram on page 98.

15. **Like the waters** of the ocean, the greatest thickness of the atmosphere is in latitudes 28° to 35°. The decrease in thickness towards the poles, although not great, is nevertheless perceptible.

16. **The uneven distribution** of the air is shown in the accompanying table, being the average of many years observations at the sea-level.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Christianburg**.. | Latitude, 5° 30′ | N. | 29.92 in. | **Tripoli** ...... | ...Latitude, 38° | N. | 30.21 in. |
| **St. Thomas**..... | " 19° | " | 29.94 " | **Florence**........ | " 43° 30′ | " | 29.99 " |
| **Macao**.......... | " 23° | " | 30.03 " | **Dantzic**.......... | " 54° 30′ | " | 29.92 " |
| **Teneriffe**........ | " 28° | " | 30.08 " | **Reikiavik**....... | " 64° | " | 29.61 " |

17. **Effect of Altitude.**—It is also evident that as one ascends above the sea-level the mercury will fall, because there is less air to balance it. Careful observations show that this difference is about one-tenth of an inch for every ninety feet.

18. **Torricelli's Experiment.**—The discovery of this principle was made by Torricelli (*Tor-e-chel'-ee*), a pupil of Galiléo. The conclusion that the barometric column is sustained by the pressure of the air, was denied by philosophers of that time.

19. **Pascal's Proof.**—Pascal (*Pas-kahl'*), a young French scholar, convinced of the truth of Torricelli's reasoning, proposed to decide the matter in a practical way. He measured the height of the mercury at the base of a high mountain, which he immediately afterward ascended, again measuring the height of the column.

20. The result proved the truth of his theory: the column of quicksilver steadily fell till he reached the summit of the mountain; and, as he descended, the mercury rose again to its former height, thus conclusively proving Torricelli's theory.[1]

21. **The weight** or tension of the atmosphere may be readily found by observing the height of the mercury in the barometer tube. This, we shall see, constantly changes.

[1] Since the time of Pascal and Torricelli many improvements have been made in the form of the barometer, without, however, deviating in the least from the law established by these scholars.

The following shows the effect of altitude upon the barometric column:—At the level of the sea, the column is 30 inches; at 3.4 miles above the sea, it is 15 inches; at 6.8 miles, 7.5 inches; at 10.2 miles, 3.75 inches; at 13.6 miles, 1.87 inches; and at the height of 17.0 miles, .94 inches. In other words, the weight and density of the air are halved for every 3.4 miles above the sea-level. The highest altitude ever reached by a balloonist is about 7½ miles. At this height the barometer fell to 7 inches. At the present time, the barometer is one of the most useful of all instruments in measuring the altitude of mountains.

22. **Movements of the Atmosphere.**—Like the ocean, the air is subject to great disturbances. There are tides, currents, and irregular movements of the atmosphere on a scale grander even than those of the sea.

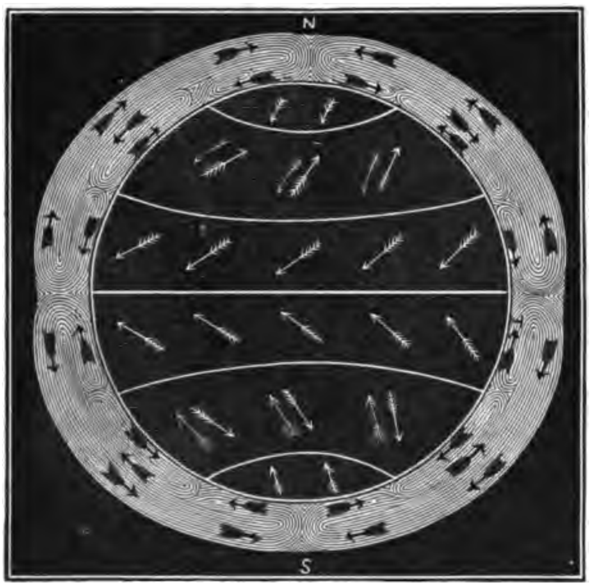
23. **Winds.**—Movements of the atmosphere are called winds. They may be constant and regular, or they may be irregular. The former comprise those which blow steadily, with constant force, and in certain known directions, during a fixed period.

24. These winds are usually confined to the ocean and sea coasts. They are known as *trade winds, passage winds, polar winds, monsoons,* etc.

25. **Cause of Winds.**—The heat of the sun, the prime cause of ocean movements, also causes those of the atmosphere, and the laws which govern one likewise control the other.

26. **The general movements** of the air, like those of the ocean, originate in the equatorial regions. Wherever the sun's rays fall vertically on the earth, the air becomes heated, and therefore, expanded.

27. **The heated air**, being bulk for bulk lighter than cold air, rises; at the same time, cold air is pushed in to fill the vacant space.



The Circulation of the Atmosphere.

28. This may be easily illustrated by throwing bits of tissue paper upon a hot stove. They are at once carried upward by the rising current of air. To fill the place of this, cold air is forced in on all sides.

29. **Direction of Winds.**—If now we apply the same reasoning to the atmosphere of the Earth, we shall find that the general movements are similar.

30. These are chiefly—*An upward current in equatorial regions, which sets toward the poles.*[1]

*Currents of air towards the equator to replace that which has risen.*

*Polar currents blowing toward the equator.*

31. These laws are greatly modified, not only by the spinning of the Earth on its axis, but also by the continental land masses.

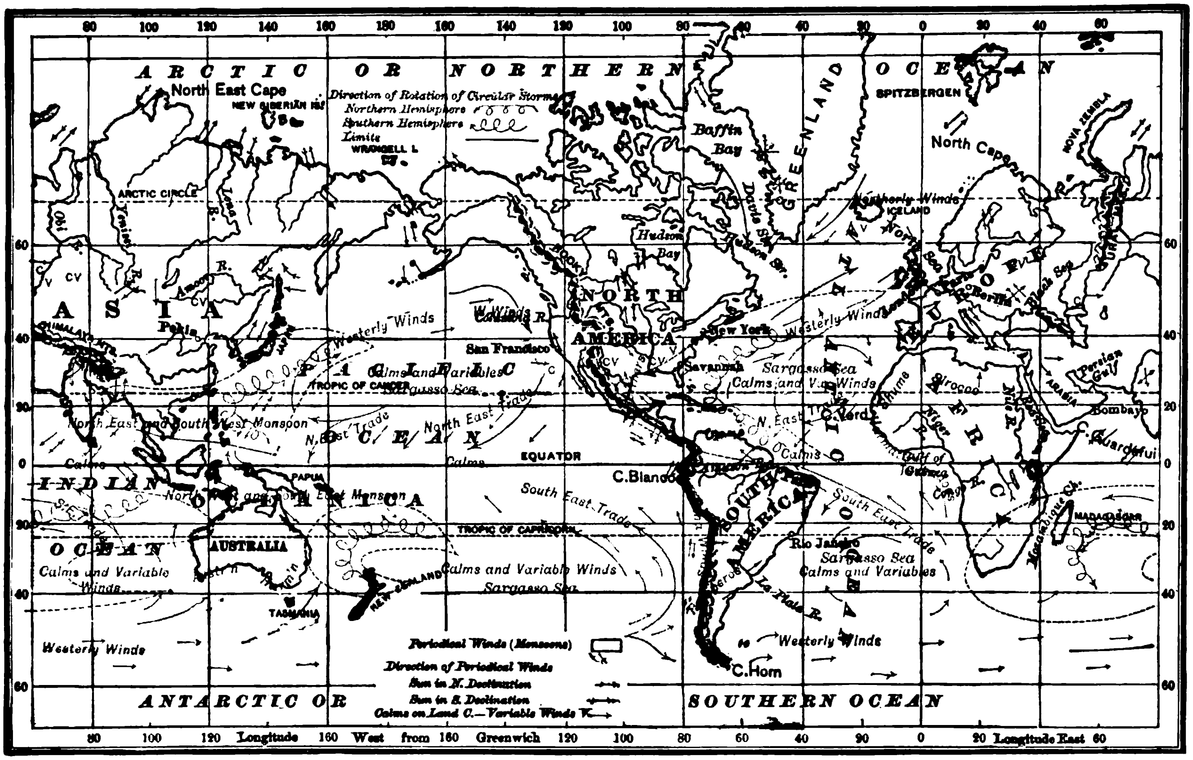
32. **Effect of the Earth's Rotation.**—The rapid motion of the Earth on its axis from west to east modifies the direction of the winds blowing toward the equator, so that north of the equator, they blow towards the southwest, and south of the equator, towards the northwest.

33. **Trade Winds.**—These winds, on account of their favorable direction to vessels plying on certain commercial routes, have been named trade winds. They are constant throughout the year, blowing not only with regularity but also with a uniform velocity.

34. The belt or zone of trade-winds, moves a few degrees northward, during the summer of the northern hemisphere and southward, during the winter. Their northern limit in summer is about latitude 24° N.; in winter, about latitude 5° N.[2]

[1] The upward current is in the latitude *where the sun's rays are vertical.*

[2] Reports of U. S. Hydrographic Office.




Wind Chart.—Heavy arrows show direction of ocean currents.

35. **Variables and Passage Winds.**—By the time the warm, upward currents of air from the equator have reached temperate latitudes, they have become cold and sink to the surface. Here, on account of the Earth's rotation, they have a northeasterly direction in the north temperate, and a southeasterly direction in the south temperate zone.

36. These winds, often called passage-winds, are neither so regular nor so constant as are trade winds. In fact, they often blow in an opposite direction, and in consequence, are often called *variables.*[1]

37. **Polar Winds.**—The polar winds also have a slight westerly movement, owing to the Earth's rotation. These winds are tolerably constant and, of course, blow towards the equator. They are met with in latitudes as low as 70°.

38. **General Law of Winds.**—By looking at the chart on page 90,you will notice that there is a striking similarity in the motion and direction of the atmosphere and those of the water. These may be summed up as *a general westward motion in the equatorial regions, and a general eastward motion in temperate latitudes.*

39. **It is in the ocean** only that these laws may be best observed. On the land and near the coasts,they do not always hold true.

[1] It will be seen by consulting Prof. Ferrel's chart, that in the temperate zones there are currents blowing in nearly opposite directions, one above the other. Sometimes,the upper current prevails, or rather sinks to the surface of the Earth. Whenever this occurs,the winds of the north temperate zone have a southwesterly direction near the tropics, and a south-easterly direction in the northern part of the zone.

40. **Monsoons.**—Near all southern and western coasts, there are winds blowing in a certain direction for six months, and then for six months in an opposite direction. These winds are the *monsoons.*

41. **The best example** of such winds occurs in the Indian ocean. The monsoons blow from the northeast in winter, and from the southwest in summer.

42. **The northeast winds,** blowing over land, are dry, and quickly parch the face of the whole region over which they blow.

43. **The southwest monsoons**, however, coming from the ocean, are warm and moist. They pour their waters upon the parched country, which soon teems with life.[1]

44. **Region of Monsoon Winds.**—The chief monsoon regions of the western hemisphere are in the Gulf of Mexico and along the western coast of Mexico. They occur as far north as Bering sea, where they are even more noticeable than in lower latitudes.

45. **Zones of Calms.**—There are narrow belts in several latitudes where the winds seldom blow, and where they are even then very irregular. These belts are the *calms.* They are not always in the position laid down on the chart, for they move north or south a few degrees with the sun.

Sea Breeze.

46. The reason why these calms exist is not with certainty known. The equatorial calms are usually attributed to ascending currents of air in latitudes where the sun's rays are vertical. For a similar reason, the calms of Cancer and Capricorn are attributed to descending currents at the tropics.

47. Vessels passing through these calms drift helplessly about for weeks, or perhaps months. These belts are called "horse latitudes" and "doldrums" by sailors. The equatorial calm-belt lies a few degrees north of the equator and never passes south of it. (See Illustration, p. 80.)

48. **Irregular Winds.**—On large bodies of land, and especially at some distance from the sea coast, regular winds, such as the trades and passage-winds and the monsoons, are greatly modified; and in many localities, they are entirely unknown.

49. This is generally true of eastern coasts in temperate, and western coasts in equatorial latitudes; for you will see, by looking at the Chart of Winds, that here the winds blow from the land instead of from the sea.

50. In such localities, and also at a distance from the sea, the winds are local and irregular. They are caused by the heat of the Earth, and they are liable to change their direction or to cease at any moment.

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[1] There is no sufficient reason for regarding these monsoons as the changing of the trade-winds. They do not correspond with them either in direction, force, or temperature.

Land Breeze.

51. **Land and Sea Breezes.**—Along warm coasts, there is a wind called the "land-and-sea" breeze that is tolerably regular.

52. **During the day,** the land receiving more heat than the water, heats the air, which rises. The cooler air immediately blows in from the sea to fill the place of the rising current, thus making the *sea breeze.*

53. **At night,** the land parts with the heat so readily that it soon becomes cooler than the water. The cool air is heavier than the sea air, which rises, and its place is filled by the colder air blowing from the land. This produces the *land breeze.*

## WHAT HAS BEEN TAUGHT IN CHAPTER XVI.

***The atmosphere extends above the surface of the Earth to a height estimated between 50 and 200 miles.***

***At the sea-level, the weight of air is one-eight-hundredth that of water.***

***Air is composed of nitrogen, oxygen, and carbon dioxide gases, together with a varying amount of the vapor of water.***

***Its weight or pressure on the Earth's surface is determined by measuring the height of a column of mercury, which the air balances.***

***The weight and pressure of the air vary, the variations being noted by the barometer.***

***At the level of the sea the pressure of the air is nearly 15 lbs. per square inch, supporting a column of mercury about 30 inches in height.***

***The falling of the barometer indicates a decreased, and the rising, an increased height of air overhead.***

***The weight of the air decreases rapidly as the altitude increases, the barometer falling one-tenth of an inch for every 90 feet of ascent.***

***The air, like the waters of the ocean, is in constant motion.***

***The constant winds consist of upper currents from the equator towards the poles, balanced by a counter movement of currents from the poles to the equator.***

***The regular and constant currents of air resemble those of the ocean, being produced by the expansion of air heated by the sun.***

***These movements are, by the Earth's rotation, modified to a northwesterly direction south of the equator, and southwesterly course north of it, being known as trade-winds.***

***In the temperate zone, the general motion of the air is eastward; northeastward in the north temperate, and southeastward in the south temperate zone.***

***On western and southwestern coasts, winds called monsoons, prevail, blowing in a certain direction for six months, and in an opposite direction, the remainder of the year.***

***Monsoons are alternately wet and dry winds, as they blow over the sea or over the land.***

***At the equator and the tropics are zones having no regular wind, called calm-belts.***

***Regular winds, such as the trades and the monsoons, are not perceived inland, except at great altitudes.***

***The surface of the Earth becomes greatly heated, and the rising of the hot air produces local winds which may blow in any direction.***

***Along the coasts, these local winds are chiefly land-and-sea breezes which blow from the sea in the day-time, and from the land at night.***

# CHAPTER XVII.

## STORMS, CYCLONES, AND TORNADOES.

Waterspouts.

1. **Cause of Irregular Winds.**—A falling barometer always indicates wind blowing from all directions towards that locality where the barometer is lowest.

2. **The reason** for this is not difficult to understand. Whenever the barometer falls, it shows that a less weight of air is pressing upon the mercury at that particular place, than elsewhere.

3. **The lighter pressure** may result from rising currents of warm air, or it may be that a great amount of vapor is present.[1]

4. **Area of Low Barometer.**—In either case, air will be forced in from all sides until the pressure is again equal. More certainly does wind follow if there is a rain storm within the area of low barometer, because when the vapor in the air is changed to rain, a great amount of heat is set free.

5. The heat thus set free warms the air, which rises as a strong, upward current. Thereupon, the colder air is pressed in with all the greater force to fill the vacant space.[2]

6. **Relation of Low Barometer to Rain.**—The falling barometer is generally, but not always, followed by rain. This depends upon the amount of moisture held by the air in the area of low barometer.

7. **The rising column** of air may have a temperature of 80° F., and may therefore contain as much as 10½ grains of water per cubic foot.

8. For every 183 feet of ascent, **it will be cooled** 1° F. If it rise 1830 feet, its temperature will fall to 70°, and the air can then hold but 8 grains of water per cubic foot. Therefore, all the moisture in excess of this will be precipitated in the form of rain.

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[1] The specific gravity of the vapor of water is .61; that is, the vapor of water is about three-fifths as heavy, bulk for bulk, as air.

[2] **To the Pupil.**—You will recollect that the heat set free when water changes from a vapor to a liquid, is called *latent heat* (see Chap. ix., p. 57). When water is changed to steam, a great amount of heat is *absorbed*, and disappears or becomes "latent." But if the steam is again changed to water, all of this heat is set free. The heat thus set free, when one pound of steam is changed to water, is sufficient to heat 5.37 pounds of water from the freezing to the boiling point, or 967 pounds of water 1° F.

Formation of Whirlwinds.

9. **Desert Whirls.**—No one who has traveled through dry, sandy plains has failed to notice the whirlwinds that occur so frequently in those regions.

10. **These whirls are most frequent** in the morning when the air is at rest, and *never* when a breeze is blowing. The sun's heat and the absence of wind satisfy all the conditions necessary to produce whirls of this kind.[1]

11. **The lower layer of air** has been warmed by the hot Earth until it has a temperature of perhaps 90° F. The upper layer at a distance of 3,000 feet or more is scarcely 75° F., being 1° cooler for every 183 feet.

12. **This position** of the two layers of air is a very **unstable** one, because the air next the Earth is much lighter than that above it.

13. By and by, some slight disturbance starts a slender column of air upward. Immediately, the pressure of cold air forces the warm air upward through the opening.

14. **The warmer air,** pressed towards the channel up which it passes, moves with enough force to carry a cloud of dust and fine sand. This is carried upward until it ascends hundreds of feet into the air.

15. As the air from the surface blows from all directions towards the rising column, the latter soon begins a whirling motion. The upward rush, as well as the whirl, increases in velocity, until the warm air has ascended, and the colder layer has sunk to the ground.

16. On deserts and arid plains, these whirls begin as soon as the sun is two or three hours above the horizon. Sometimes, several of them may be seen rising as slender columns, each several hundred feet in height. During the morning, a gentle wind sets in, which, by mixing the warm with the cold air, prevents their further formation.

17. **The whirlwinds of the desert** differ from the cyclones of the Indian ocean, the hurricanes of the West Indies, and the typhoons of the China Sea, in violence only.

18. **Waterspouts.**—Waterspouts are caused in the same manner as the desert whirls. The whirl that makes a waterspout must have sufficient velocity to form a vacuum at its center. Into this center the water is drawn—or rather forced. It rises a few feet as a solid column, and then breaks into a dense cloud of spray and vapor.

19. **Effects of Heat and the Earth's Rotation.**—In these storms are two elements which make them terribly destructive, viz., the heat set free by the condensation of the vapor in the air, and the rotation of the Earth on its axis. The former causes the storm to move in certain known directions, while the latter gives to it its great violence.

20. **Cyclones.**—In the chart at the top of the next page, is shown the usual path of these whirling storms upon the ocean. They vary from 200 to 500 miles in diameter, and they often travel 2,000 or 3,000 miles before their fury is spent.

[1] The whirlwinds here mentioned are not like those formed at street corners where opposing currents of air meet.

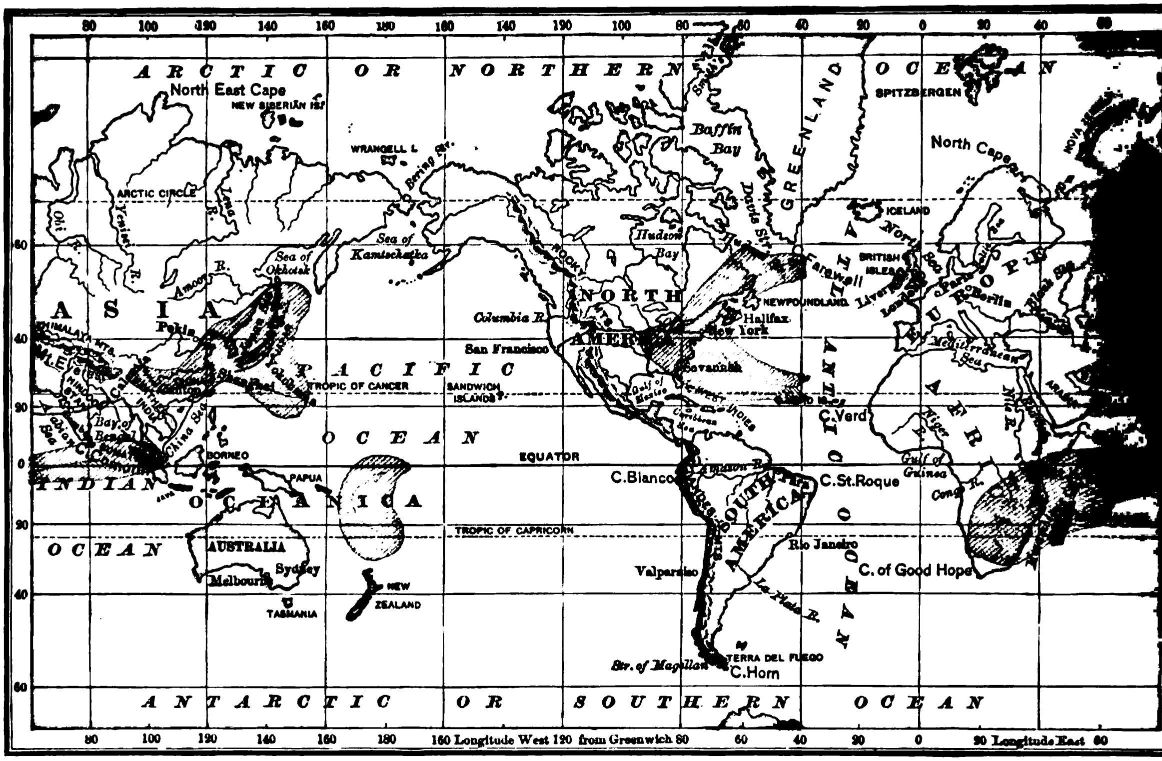



Chart Showing the Region of Cyclones.

21. **The storm does not cease,** until it has extended into temperate latitudes. Here the atmosphere does not contain so much moisture—for it must be borne in mind that *the heat set free by the condensation of moisture is the fuel of cyclones*—and the storm finally ceases.

22. Notice that these storms have the same direction as the regular winds—westward in equatorial regions and eastward in temperate latitudes. They always originate in the equatorial calm-belt or doldrums, but they never occur within eight or ten degrees of the equator.

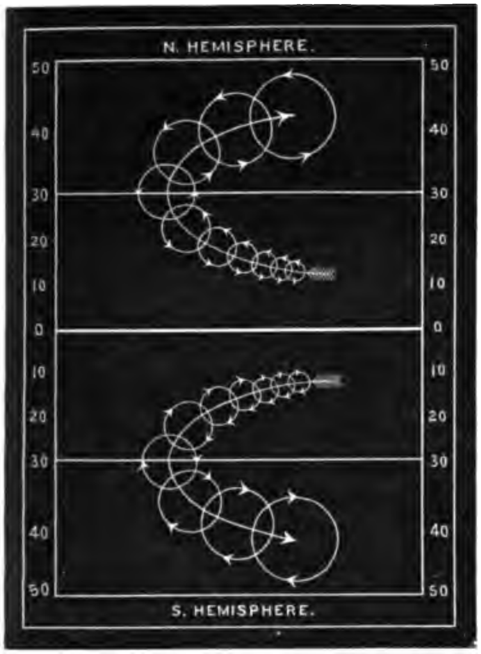
23. Like the desert whirls, the beginning of the cyclone is a dead calm, for it is such a condition only that will permit the lower layer of air to become heated.

24. **The whirl** is from right to left in the northern and from left to right in the southern hemisphere. The velocity of the wind in its whirling motion, varies from 50 to 125 miles per hour. The storm moves at a rate varying from 10 to 50 miles per hour.[1]

[1] The first warning of the cyclone is indicated by the barometer. The dead calm which has prevailed for some days, perhaps, is really a part of the storm; for it was during this calm that the conditions necessary for a cyclone were provided.

There may not be a cloud in sight nor a breath of air stirring. The barometer begins to show a slight unsteadiness, and possibly a streamer or two of cat-tail clouds, pointing towards the zenith, may be seen in the south or southeast. Soon the barometer begins to fall, slowly at first, and then more rapidly. Fitful puffs of wind come from the north. The sky grows purple, and the sea begins to heave in turbulent chop-waves. There can now be no longer any doubt about the approach of a storm. Long before this, the prudent mariner has made everything in the rigging and on deck snug and close, ready for the coming gale.

Not many minutes will elapse before the wind, at first gusty and squally, bursts into a gale, and veers to the north-




The Direction of Cyclones.

25. As the laws concerning the direction and the paths of these storms are now well known, the master may, in most cases, head his vessel so as to sail out of the storm.

26. To aid him in this, storm cards are generally used. This card, placed on the sailing chart in the latitude of the vessel, will at once show the relative position of vessel, storm, and the path in which the latter travels.[1]

27. Looking in the direction from which the wind blows, the center of the cyclone is on the right hand in the Northern and on the left in the Southern Hemisphere.

28. You will notice upon the storm chart that the regions in which these cyclones most frequently occur are the track of the Gulf Stream, the track of the Kuro Siwo, the region of the Malabar current, and the eastern coast of Australia.

29. In the first two, the storm track is quite uniform ; in all of them, the cyclones are very destructive.[2]

Northern Hemisphere.


Storm Cards.


Southern Hemisphere.

east. In a moment the storm in all its fury is upon the vessel. If, by error, the master has not altered his course to the southward, he has but a slim chance of riding out of the storm with a whole vessel.

The wind now increases to a hurricane and the vessel pitches about at the mercy of the terrific chop seas, uncontrolled by helm or storm sheet. The roaring of the wind rises to a deafening pitch and comes in gusts which throw the ship on her beam ends. Canvas is blown into shreds, spars are torn off, and the masts are splintered.

In almost a twinkling, the wind ceases. The vessel is now in the center of the cyclone, or as sailors say, "in the eye of the storm." The sky is shrouded in murky blackness; rain falls in torrents; and no sound can be heard but the low roar of the retreating storm. But a short interval—scarcely half an hour—passes, before the opposite side of the storm swoops upon the vessel. Now the wind is from the southwest, its fury is not abated, and it soon finishes its work, leaving the ship helpless and water-logged,—a wreck.

[1] For instance, the vessel is in latitude 30° north, when the premonitory sign of the storm, accompanied by a north wind, appears. In this latitude, the storm will move towards the northeast. By placing the storm cards in the position of the vessel, the master at once sees that to escape the cyclone he must head his vessel south by a point or two west.

[2] The shores of the bay of Bengal frequently face the cyclones of the Indian ocean. The inblowing winds, combined with a possible high tide, pile up the water until it is poured over the levees and inundates thousands of square miles. Within 200 years, more than half a million people of India have perished from this cause alone.


Ship Overtaken by a Cyclone.

30. **Tornadoes.** — The tornadoes that sweep the Mississippi valley do not differ materially from the cyclones of the ocean, except in size.

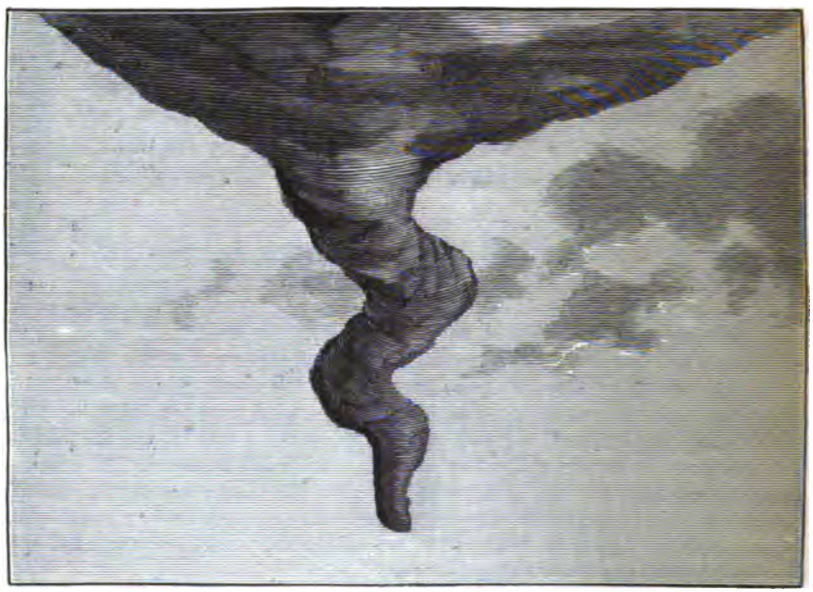
31. The whirl of these tornadoes seldom exceeds half a mile in width, while the center of the storm is never more than a few rods wide. In violence, however, they equal, if they do not surpass, the ocean cyclones.

32. Like all other whirls, the tornado is preceded by calm, sultry weather and a low barometer. It is almost always attended by a fall of hail and rain, which occurs chiefly on the outer edge of the storm.

33. Tornadoes occur, as one might suppose, with greatest frequency in the summer months. Their direction accords with the law of storms, and is therefore towards the east or northeast in temperate latitudes.

34. In the United States, tornadoes are confined chiefly to the Mississippi valley,— Kansas, Missouri, Iowa, and Illinois being most often visited.

35. At the distance of a few miles, the tornado appears as a black funnel hanging from rapidly whirling clouds. The funnel sways from side to side, often descending to the ground and dragging upon it.


Funnel Cloud of the Tornado.

36. This funnel is the center of the storm, and so rapid is the whirl, that it is almost a vacuum. Whenever it strikes a building, the latter flies to pieces with almost explosive violence.[1]

[1] It is a noticeable fact that buildings burst to pieces outwardly. In the center of the storm the atmospheric pressure is almost nothing, while within the walls of the house the outward pressure is fourteen or fifteen pounds on every square inch.

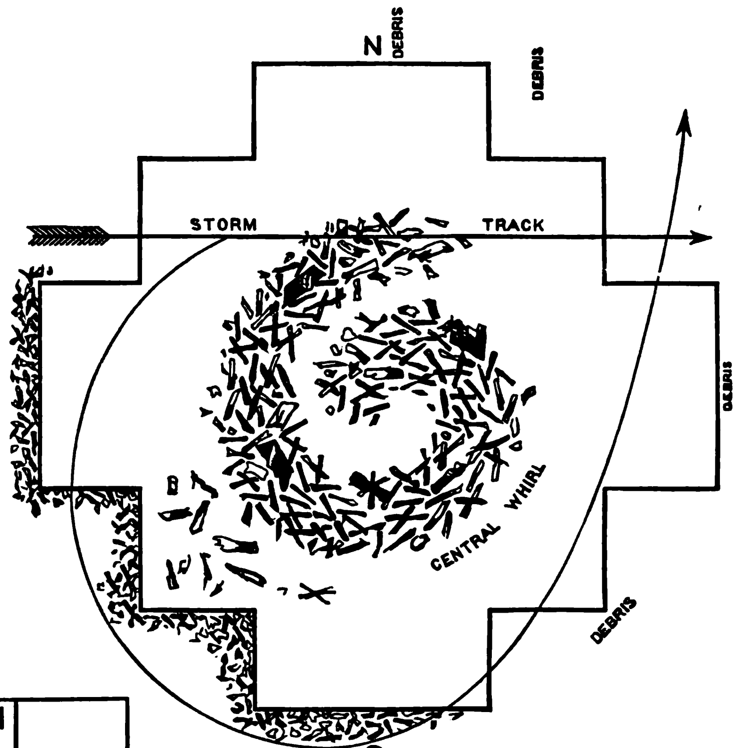
The destructive effects of tornadoes are almost beyond belief. "Heavy carts are carried through the air." "Wagon tires are broken and twisted." "Nails have been driven head first into solid planks." "Trees are *twisted* out of the ground." "Large pieces of tin piping, guttering, and weather-boarding were found six miles northeast of the house." "Twisted stovepipe, lightning-rods, and farming implements were found four miles away." At Irving, Kansas, "large oaks, three feet in diameter, were broken off like pipe-stems, and tough elms, nearly as thick were twisted into ropes." "These

37. Within the funnel, one may see objects carried upward with a whirling motion.

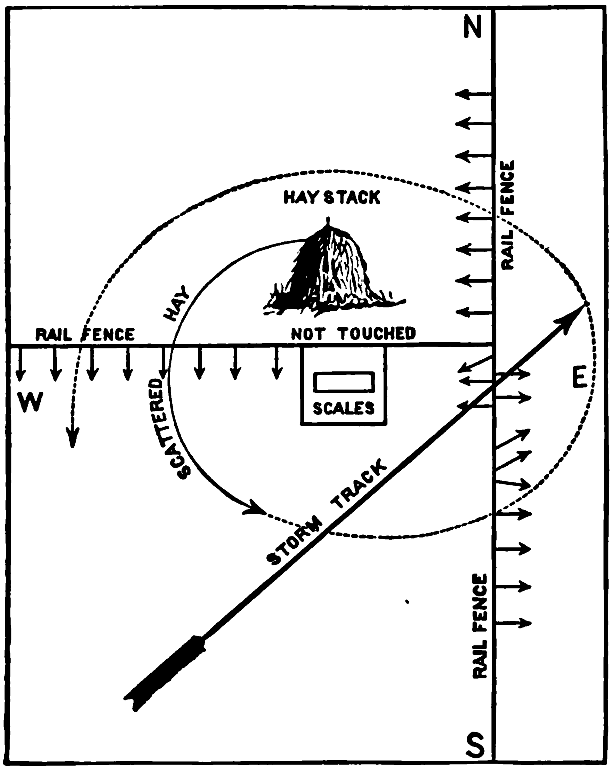
38. Since the settlement of the Mississippi valley, over 600 tornadoes have been recorded. In 40 of these, more than 1,000 persons have been killed or injured.

39. **Ordinary Storms.**—Nearly all storms have the nature of cyclones, lacking their violence, but having a much greater area.

40. Since the establishment of the United States Weather Bureau, these storms have been watched with great care. Observations are made by trained assistants at the same instant, three times a day, in about three hundred localities scattered over the United States. The results are at once telegraphed to Wasnington.




Irving (Kansas) Tornado.




Barnard (Missouri) Tornado.—The arrows show the direction in which fence-rails were thrown.

41. By means of these observations, the direction and motion of the storm are mapped out with great precision. Knowing the velocity and direction of a storm, it is not difficult to predict its entire course.

42. From observations covering a period of fourteen years, it is found that the ordinary storm consists of a center called the area of low barometer, towards which a gentle wind blows from all quarters.

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frame houses stood about in the center of the storm and were completely destroyed. . . . The father, mother, and grandmother were carried about 200 yards to the east and were found lying within a few feet of each other, dead. "A cow belonging to Mr. Martin was carried a distance of 140 rods, over the tops of trees, and set down uninjured in the mud." "Poultry are sometimes stripped of their feathers, although not always killed."—*From the Report of U. S. Signal Corps.*

43. The storms occurring in the central part of the United States originate in the Rocky mountains or the Pacific ocean, and travel eastward. Those of the Atlantic coast usually start in the Gulf of Mexico or the Caribbean sea, and follow the path of the regular cyclones.

44. The maps on page 112, taken from the records of the Weather Bureau, show the origin and the paths of these storms. In width, they vary from a few hundred to over a thousand miles. A storm which starts in the Rocky mountains sometimes travels half way around the Earth.

45. The storms of the Pacific coast often travel southeastward towards and along the Mexican coast.

## WHAT HAS BEEN TAUGHT IN CHAPTER XVII.

*The rapid falling of the barometer is always followed by wind which blows towards that point where the barometer is lowest.*

*Rain frequently follows a falling barometer, in which case the wind is apt to be stronger and of longer duration, on account of the latent heat set free.*

*The whirls often seen in deserts are caused by the air at the surface becoming heated, resting at the same time beneath the colder and heavier air above.*

*Finally, a passageway is opened through which the warm air is forced upward, while the cold air presses down to the surface of the Earth.*

*The air pushed from every direction towards this channel acquires a whirling motion as it passes upward.*

*The air becomes cooler, at the rate of 1° for every 183 feet of ascent.*

*Waterspouts at sea are caused in much the same manner as the desert whirls; but their whirl is so rapid that a vacuum is formed at the center, into which the water is forced.*

*The cyclones of the ocean do not differ from the desert whirls except in size and in violence.*

*The latent heat set free by the changing of vapor to water, and the rotation of the Earth, add greatly to the destructiveness of the storm; the former prolonging it and adding to its violence, and the latter causing it to move in certain definite directions.*

*These directions are west in the Torrid, east or northeast in the North Temperate, and east or southeast in the South Temperate zone.*

*They are from 200 to 500 miles in diameter, often traveling several thousand miles before their fury is spent.*

*The whirl is from right to left in the northern, and from left to right in the southern hemisphere.*

*The cyclone is preceded by a dead calm, which is its true beginning.*

*Cyclones usually, if not always, originate in warm ocean currents, and never within six or eight degrees of the Equator.*

*The tornadoes of the Great Central Plain are land cyclones, smaller in extent, but, perhaps, equally as violent as the cyclones of the ocean.*

*The funnel of the tornado is the center of the storm, and is almost, if not quite, a vacuum.*

*The velocity of the wind during a tornado often exceeds 100 miles per hour, the tornado moving east or northeast.*

*Nearly all ordinary storms are of the nature of cyclones, lacking, however, their violence.*

*They consist of a center, called the area of low barometer, towards which the wind blows with a spiral motion, from every quarter.*

*Most of the great storms of the United States originate in the Rocky mountains, or, perhaps, in the Pacific ocean.*

*They travel eastward or northeastward, and frequently cross the Atlantic ocean, before they are spent.*

*Many of the severe storms of the Atlantic coast originate in the Caribbean sea or the Gulf of Mexico, and travel in a northeasterly direction along the coast.*

# CHAPTER XVIII.

## CLIMATE.

An Arctic Scene. Effect of High Latitude and Oblique Rays.

1. **Causes of Difference in Climate.**—The climate of a country is its condition with respect to heat and moisture.

2. Every country in the world has certain peculiarities of temperature, winds, and rainfall, which, together with its general situation, render it different from all other countries.

3. These differences are due to a great number of causes, of which the principal are enumerated below. The first two of these are astronomical; the others are physical modifications of climate.

Latitude.
Inclination of the Earth's axis.
Direction of winds.
Direction of ocean currents.
Height above the sea level.
Distance from the ocean.
Position and distance of high mountain-ranges.

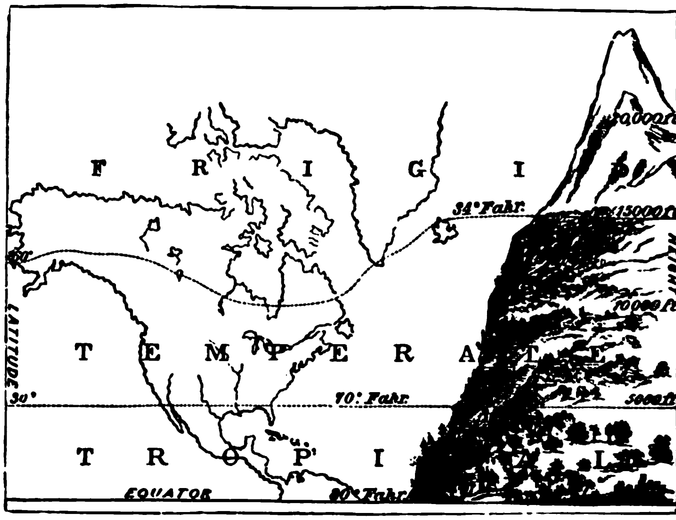
4. **Source of Heat.**—The sun is the source of all heat apparent upon the surface of the Earth, no matter whether we consider the scorching beams pouring down upon the arid desert, the coal fire within the grate, or the back log on the hearth.

5. In every case, the heat comes directly from the sun, or else it is heat-producing fuel that has been stored up by the sun in ages past.[1]

6. **Altitude.**—Elevation above the sea-level has much to do with the temperature of a place. In a previous chapter, we learned that the air becomes cooler by one degree in every 183 feet of ascent above the sea-level. The effect of this is obvious.

7. **In the Torrid Zone,** at an elevation of from 14,000 to 16,000 feet, we find the limit of perpetual snow; while between the snow-line and the sea-level, almost any medium temperature may be found.[2]

8. **Many important cities** of South America are situated within the torrid zone. Quito, Cuzco, Potosi, and Pano have an elevation varying from 9,500 to 12,000 feet. Their great elevation renders their climate cool and delightful.




Effect of Altitude. Climates between the equator and the north pole correspond with those on the sides of high mountains at the equator.

9. **The city of Mexico** has an elevation of 7,400 feet. Vera Cruz, in the same latitude, is at the sea-level. Few cities in the world have a climate so agreeable and healthful as that of Mexico. That of Vera Cruz, on the contrary, is very hot, and at times pestilential.

10. **Distance from the Ocean.**—Distance from the sea affects chiefly those localities over which the trade or other sea-winds blow. As the distance from the sea increases, the daily variations in temperature are likewise greater. The amount of moisture contained in the air and also the amount of rainfall usually decrease.

11. **In the vicinity of sea-coasts,** climate is greatly tempered by the rapid evaporation of ocean waters, whereby an enormous amount of heat is transferred from warmer to colder regions.

12. You will recollect that when water is changed to vapor (see p. 57) a great amount of heat is absorbed. If the vapor with its stored-up heat be now carried by winds to colder localities, and again changed to water, all this heat is again set free.[3]

[1] In its *ordinary* sense, combustion or burning means a chemical combination of carbon with oxygen. When the carbon of the coal or the wood unites with the oxygen of the air, very great heat is evolved, and carbon dioxide, commonly called carbonic acid gas, is formed. Sunlight and heat have the power of separating these elements which have formed the carbon dioxide. The green leaves and blades of grass are nature's laboratory wherein this work is done. The carbon is restored to the plant, while the oxygen is given to the air.

[2] The limit of perpetual snow varies with latitude. In Patagonia, it is about 3,000 feet; in Chili, 8,600 feet; in Bolivia, 16,000 feet; in the western slope of the Sierra Nevada mountains, 10,000 feet; and at cape North, 2,400 feet.

[3] More than 100,000 cubic miles of water are each year taken up, in the form of vapor, from the ocean, and again deposited as rain or as snow. If one-fourth of this amount be carried to temperate and to polar latitudes, the heat thus transferred would be sufficient to raise nearly 180,000 cubic miles of water from the freezing to the boiling point. "We can scarcely form a too greatly exaggerated estimate of the tempering of climate by rain-bearing winds."

13. Hence we learn that all moisture-laden winds are warm, if only the vapor they contain be condensed and the heat thereby set free.

14. **Consulting the wind chart** on page 99, you will find that the moisture-bearing winds of the temperate zone are the ocean winds blowing from the west. The effect of these winds upon the climate is marked—*all western coasts in the temperate zones are much warmer than eastern coasts in the same latitudes.*

15. **Ocean Currents.**—The presence of warm ocean currents has likewise a moderating effect upon climate. The warmth derived from them, combined with the latent heat transferred by evaporation, make them the most powerful of all physical agencies in tempering climate.

16. **The British Islands**, lying in the same latitude as **Labrador**, are seldom covered with snow for more than a few days at a time, and ice never forms in their harbors. Labrador, on the contrary, is covered with ice and snow during eight months of the year, and, in some places, its coast is ice-bound even in midsummer.

17. **Norway** and southern Greenland lie between the same parallels of latitude. The former has a climate hardly so cold as that of Maine. The port of Hammerfest, situated within the frigid zone, is free from ice-drifts and open to commerce throughout the year.

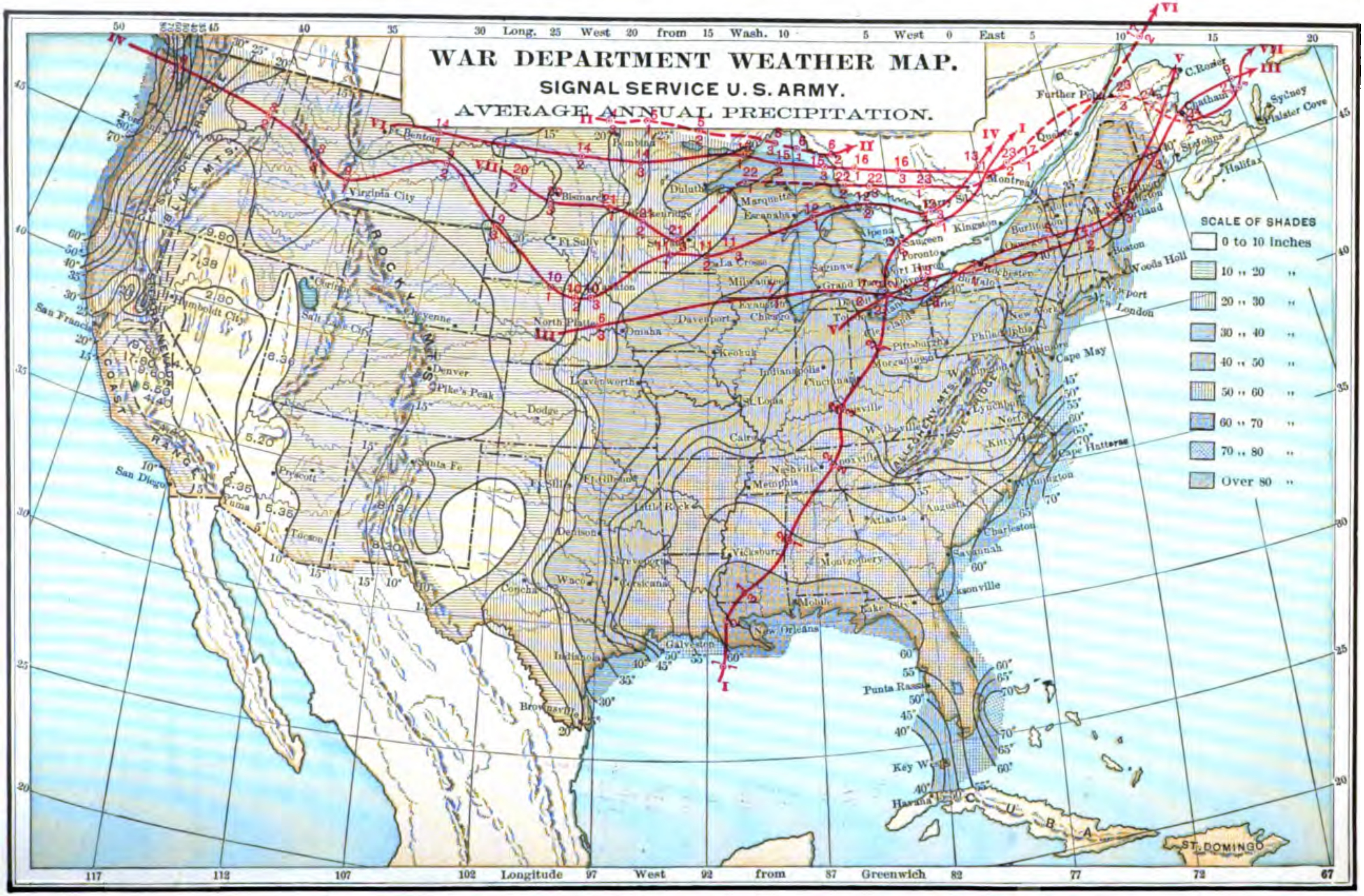
18. **Greenland**, on the other hand, is shrouded in a perpetual winter. Except a few portions of land bordering its southern coast, the whole surface has been for ages covered with ice and snow.

19. These great differences in climate are the work of the physical agents we have considered in the preceding paragraphs, viz.: the winds, the latent heat of water transferred by the winds, and the warm ocean currents.


Scene in Florida—Effect of warmth and moisture.

20. **Variations in temperature** during the year will, for the foregoing reasons, be much greater on eastern than on western coasts of the temperate zones, and they will be greater in the interior of a continent than on either of its coasts.[1]

[1] The following low temperatures have been registered by the Signal Service Bureau: Fort Buford, Dakota, – 40°; Pembina, Dak., – 48°; Fort Ellis, Montana, – 53°; Fort Brady, Mich., – 55°. Lt. Schwatka, the Arctic explorer, recorded a temperature of – 70° in King William's Land. It is doubtful if a hotter region exists than the Colorado desert in southeastern California. A temperature of 135° has been registered, and it frequently exceeds 120°.




The long, red arrows indicate the locality in which each storm originates, the direction in which it moves, and the track over which it travels. They constitute the record of storms for one month.

The Roman numerals show the order in which the storms occurred. The figures (in red) over the path of the storm stand for the day of the month; those under the line, the order of observation. A broken line indicates that the observations were incomplete or of doubtful value.

The heavy, black figures indicate the number of inches and hundredths falling on the Great Basin. The figures at the ends of the irregular, black lines show the number of inches of rain.

This is shown by the following records from the Weather Bureau—Report of 1881:

| LOCALITY. | SITUATION. | AV. OF COLDEST MONTH. | AV. OF WARMEST MONTH. | GREATEST MONTHLY RANGE. |
|---|---|---|---|---|
| **Los Angeles, Cal.......** | Western Coast.......... | 49.1° | 69° | 29° |
| **San Francisco, Cal....** | Western Coast.......... | 49.6° | 59.6° | 38° |
| **Boston, Mass...........** | Eastern Coast.......... | 32.6° | 69.9° | 69° |
| **Bismarck, Da.........** | Interior................. | —1.2° | 70° | 83° |

21. **Distribution of Rain.**[1]—The rain or snow falling on the land in one year would, if evenly distributed, form a layer of water exceeding three and one-half feet in thickness. The distribution of the rainfall, however, is by no means even. Many parts of the Earth are constantly deluged with rain, while others receive but little or, perhaps, none at all.

22. **Periodical Rains.**—There is also a great difference in the seasons during which rain falls. In some localities, rain may fall during any part of the year; in others, it falls during the winter months only.

23. It may be stated, as a general law, that periodical rains occur along the western coasts of countries lying within the temperate zones, and in those regions over which monsoons blow.

24. In the Torrid zone, and especially near the equator, rains fall almost incessantly during a great part of the year. Towards the tropics, however, the rains are more periodical in their occurrence.

25. The "rain-belt" does not go south of the equator. For this reason, the rainfall is more periodical south of the equator than north of it. In the Torrid, as in other zones, the rain comes with the sea-wind.

26. The northern part of South America is so situated as to receive the full force of this rain-bearing wind. In consequence, the whole region is drenched with rain during much of the year.

27. **The Andes Mountains** on the western border, rising nearly as high as the rain-clouds themselves, condense most of the remaining moisture, so that little or none falls on the western slope.

28. **In the Temperate zones,** the conditions are very different. Here, the rain-winds, which are in part monsoons, blow from the west or from the southwest. Hence, the western slopes are well watered, while east of all high mountain-ranges, the rainfall is very meagre.

29. The desert of Atacama (*ah-tah-kah'mah*) in South America and the Great Basin of the United States are fine illustrations of this law. The rainfall of these regions seldom exceeds eight or ten inches; while on the opposite slopes, it often reaches 120 inches annually.

30. **Rainfall of the United States.**—In the United States, the amount of rainfall varies greatly, ranging from a few inches to more than 100 inches yearly. By consulting the Chart on p. 113, it will be seen that the Great Basin receives less rain than any other part of the country. For the past thirteen years, the rainfall of this region has averaged less than ten inches yearly.

[1] The rainfall of a country includes also the number of inches of *melted snow.*

31. **The northwestern** and the **southeastern coasts** receive the greatest amount of rain. In these localities, the annual fall varies from 65 to 100 inches or more.

32. **In the Rocky mountains** and throughout the western highlands, the average fall is about fifteen inches.

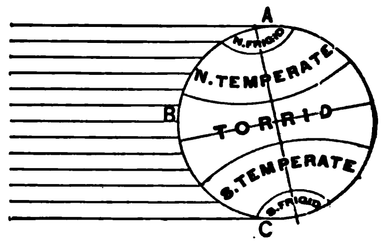
33. **The Mississippi valley** and the Atlantic slope are, however, much more plentifully watered, receiving from thirty-five to sixty-five inches of rain yearly. The former is about the amount falling upon the "wheat" states; the latter, on the "cotton" states.

34. **On the Pacific slope,** the rainfall increases uniformly towards the north. In the Mississippi valley and on the Atlantic coast, the increase is toward the southeast. Little or no rain falls on the Pacific slope during the summer; and in this region, thunder and lightning are almost unknown.[1]

35. **Astronomical Causes of Climate.**—There are certain changes of climate due to the direction in which the sun's rays strike the Earth—whether vertically or obliquely. These changes are greatly increased by the inclination of the Earth's axis.

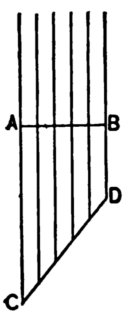
36. The Earth's distance from the sun is so great that those rays which reach the Earth are practically parallel; but as the surface of the Earth is curved, it is evident from the accompanying illustration, that while some rays strike the surface vertically, others meet it obliquely.

37. The rays both of heat and light reaching the Earth at B are perpendicular. Those meeting the surface towards A and C, however, strike more and more obliquely, until, at those points, they pass the Earth without touching it.



Effect of Curvature.

38. Whenever the sun's rays strike the Earth's surface vertically, much of the heat they contain is absorbed, being used in heating the Earth and the atmosphere. The oblique rays, however, part with much less of their heat, which, like the light they bear, is reflected away.[2]



Oblique Rays.

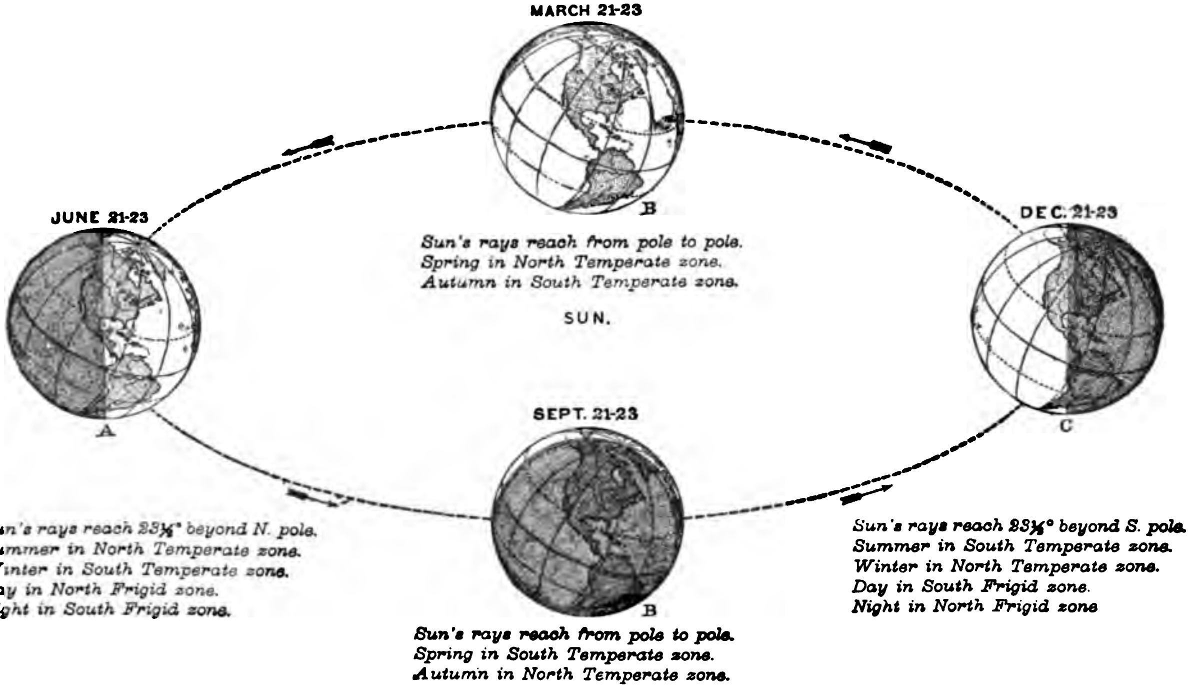
39. Another reason why the small amount of heat is derived from the oblique rays is the fact that the heat is spread over a much greater surface than would be the case if the rays were vertical.

40. This may be seen in the following diagram. The sun's rays falling in the surface A B are vertical. The same amount of solar heat, however, falling on C D, a surface twice as large, is distributed over twice as much space.

41. Hence, we are able to understand that the climate of a country, so far as temperature is concerned, depends more upon latitude than on any other one cause. Within the Torrid zone, where the sun's rays are always vertical, or nearly so, a perpetual warmth of summer obtains, while toward the poles, the climate gradually becomes one of icy coldness.

[1] From late investigations, it seems probable that the rainfall of a country is subject to changes which require long periods of time to complete.

[2] We are less sensible to the direct heat of the sun than we are to the heat radiated from the Earth and the air. It frequently happens that the sun's rays will scorch and blister the skin, while at the same time the weather seems uncomfortably chilly. There is no paradox about such a condition of weather; it is cold because the ground and the air have not been warmed. It is well to bear in mind that the heat which is required to warm our bodies comes to us second or third hand—that is, from the Earth and the air.




The Change of Seasons.

42. Were the position of the Earth's axis perpendicular to the plane of the orbit[1] there would be no changes in the climate of any locality. Each place would have a tolerably uniform temperature throughout the year.

43. **Change of Seasons.**—But on a large portion of the Earth, there are alternations of climate, which are called "change of seasons." These changes are due to the inclination or tipping of the Earth's axis.

44. **The axis of the Earth** (except as indicated in note, p. 9) preserves a direction that does not change, making an angle of about 23½ degrees with the plane of the Earth's orbit, and pointing towards the north star.

45. By studying the diagram above, you will notice that in the month of June the Earth's axis is inclined so that the sun's rays are vertical at the Tropic of Cancer. They are very slightly oblique in the North Temperate zone, while they reach 23½ degrees beyond the north pole, marking the position of the Arctic circle.

46. In this position of the Earth, it is the season of summer in the North Temperate zone, and both summer and day-time in the North Frigid zone.

47. In the southern hemisphere, the sun's rays are oblique, and lack 23½ degrees of reaching the pole. This is the winter of the South Temperate and night of the South Frigid zone.

48. By the middle of September, three months afterward, the Earth has reached a position in her orbit where the sun's rays reach each pole. This season is the autumn of the Northern and the spring of the Southern Hemisphere.

[1] The meaning of "plane of the Earth's orbit" may be illustrated by thrusting a knitting needle through an orange or a ball, and suspending it *one-half* submerged in a vessel of water. Incline the ball until the knitting-needle makes an angle of 23½ degrees with a vertical line. The surface of the water represents the plane of the Earth's orbit.

49. By the 21st of December, the Earth has passed half-way round the orbit. Now, the sun's rays are vertical at the Tropic of Capricorn, and very oblique in the North Temperate zone.

50. It is midwinter in the Northern, and midsummer in the Southern Hemisphere. The sun shines bright upon the ice-fields of the South Frigid zone, while the North Frigid zone is shrouded in wintry night.

51. **Division of Seasons.**—The division of the year into four climatic seasons is noticeable chiefly in the temperate zones, and there are parts of these zones in which the changes of season are not well marked.

52. Along western coasts of the temperate zones, there are practically but two seasons; a rainy or winter, and a dry or summer season. There are no great variations of temperature.

53. **In the Torrid zone,** the only season is that of perpetual summer. But while there are almost daily rains in parts of this zone, in other portions, the rainy and the dry seasons are distinct.

54. **In Frigid zones,** the seasons are those of day and night; the former being the summer, the latter the winter. Within the Frigid zones, the day and the night are said to be six months each in duration.

55. This is true at the poles, but not strictly true elsewhere. At the Arctic circle, for instance, the length of the day varies from 0, on the 21st of December, to 24 hours on the 21st of June. On this day, the sun does not set, its lowest position being on the horizon, or perhaps a trifle below it, if there be a land sky.

56. With each succeeding day, the sun apparently dips farther and farther below the horizon. In March and September, the sun is above the horizon twelve hours and below it twelve hours. By the 21st of December, the sun does not rise above the horizon. The day is now 0 and the night 24 hours long.

57. **At the poles,** the sun appears to sweep horizontally around the sky. Each day, it moves a little farther above the horizon, until, by the 21st of June, it is 23½ degrees high. By the middle of September, it is on the horizon, and by the 21st of December, 23½ degrees below it.

58. If the observer move a degree or two from the pole, the sun begins to show a slight variation in its distance above the horizon. This increases as the observer goes southward.

59. **Isotherms.**—Because the western coasts of the temperate zones face the warm and rain-bearing winds, it is evident that zones of equal temperature will not correspond to the astronomical zones of the Earth.

60. On the contrary, the astronomical zones of the Earth have no significance so far as climate is concerned, as they indicate neither temperature nor the distribution of moisture.

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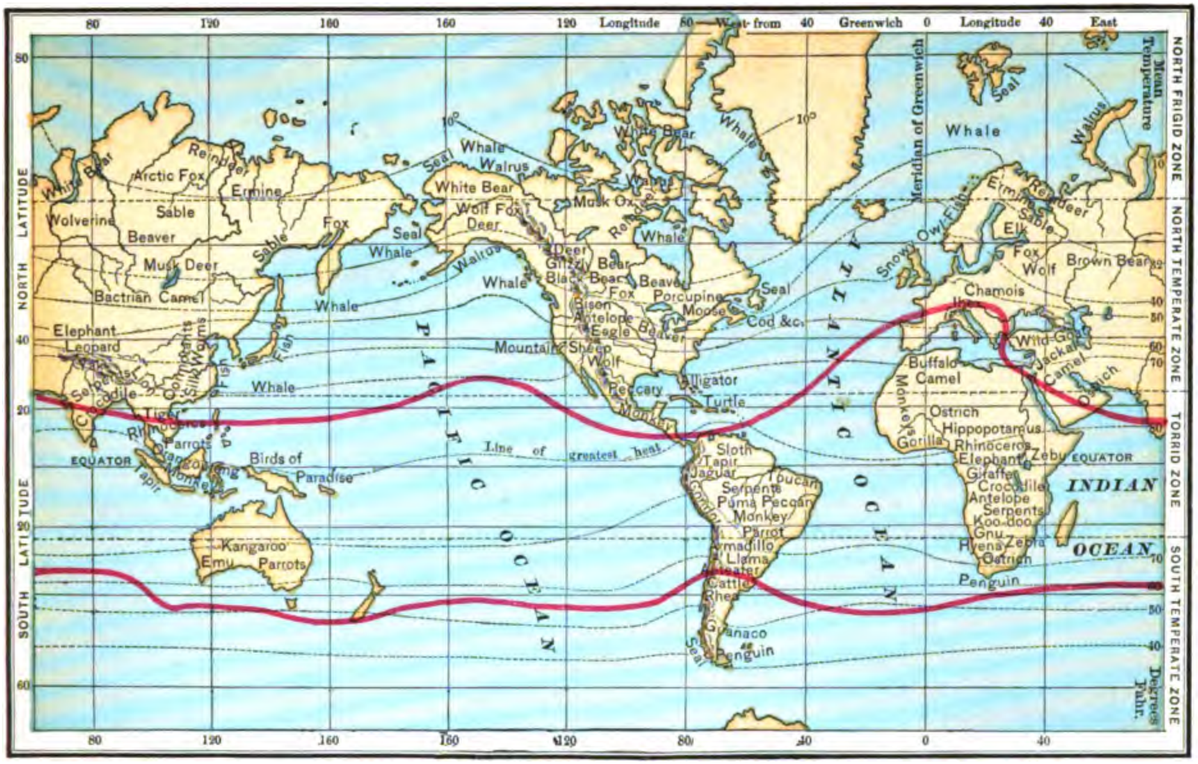
**To the Teacher.**—It should be thoroughly understood by the pupil that the Arctic and Antarctic circles mark the limit of the sun's rays beyond the pole in the frigid zones at the 21st or 22d of June and December respectively. At the same time, it may be shown that the tropics of Cancer and Capricorn mark the northern and the southern limit of vertical rays on those dates. A globe is preferable for this; but it is an excellent plan to require each pupil to construct a diagram similar to the illustration on page 115.




Isothermal Lines and Zones.

61. Each line on the map above is drawn through places having a uniform average temperature. These lines are called *isothermal lines*, or isotherms, and the zones they bound, *isothermal zones*.[1]

62. The irregularity of these lines shows the influence of winds, high mountains, and ocean currents. The hot, cold, and temperate zones of the earth are therefore bounded by isotherms, and not by parallels of latitude.

63. In the temperate zones, the isotherms bend northward as they cross to the western coast of a continent. On the ocean, the isotherms are quite regular, changing their direction but slightly; but in mountainous regions, their curves are numerous and sharp.

64. **Effect of Forests.**—Most important factors in the climate of a country are its forests. Remove the growing timber and shrubbery, and barrenness soon follows.

65. The reason for this is plain. The roots of plants not only hold much of the water in the soil, but they also hold the soil itself to the slopes and hillsides, thereby preventing its richest portions from being carried away.

66. Experience has shown that many of the disastrous river floods occurring in the United States and Europe, are due to the destruction of forests, more than to any other cause. The water that the rootlets of plants would have otherwise retained in the soil is poured into river channels, which are not large enough to contain it.

[1] From Greek words, meaning *equal heat*, or temperature.

67. A still more serious effect of the destruction of forests is the gradual decrease of rainfall. The arid condition of Syria, once the most fertile region of the world, is attributed largely to the destruction of its growing timber.

68. On the other hand, the planting of eucalyptus forests along the valley of the Nile has appreciably increased the rainfall during the past fifty years.

## WHAT HAS BEEN TAUGHT IN CHAPTER XVIII.

*The climate of a country is its condition with reference to heat and moisture.*

*The chief causes of difference in climate are latitude, inclination of the Earth's axis, winds, ocean currents, and altitude.*

*The sun is the great source of heat; the transfer of heat is accomplished by winds and ocean currents.*

*Temperature depends much on latitude, the climate being hottest at the equator and becoming colder towards the poles.*

*Temperature decreases uniformly as the altitude increases.*

*Variations in temperature are greater at a distance from the sea-coast than near it.*

*The warm winds of the temperate zones are those blowing upon the western coasts.*

*Their heat is derived from the latent heat of the moisture they contain and from the warmth of the waters over which they blow.*

*The mild temperature of the British Islands and Norway, compared with the cold climate of Labrador and Greenland, is due to warm winds and ocean currents.*

*The rainfall of different countries, or even that of different parts of the same country, is not uniform in amount.*

*The greatest amount of rain falls in the Torrid zone, near the equator.*

*Periodical rains occur usually in western and southwestern coasts of temperate latitudes.*

*In the interior, and on eastern coasts of the temperate zones, rains may occur at any time of the year.*

*The yearly rainfall of the Great Central Plain varies from 35 inches in the north, to 65 inches in the south.*

*The rains of the Pacific coast of the United States are periodical. They vary from 12 inches in the south to 100 inches in the north, and occur in winter only.*

*The decrease of temperature towards the poles is due to the oblique angle in which the sun's rays strike the Earth.*

*Changes of season are due to the inclination of the Earth's axis to the plane of its orbit.*

*On the 21st of June, the sun's rays are vertical on the Tropic of Cancer and oblique in the South Temperate zone, the seasons being respectively summer and winter.*

*On the 21st of December, the sun's rays are vertical on the Tropic of Capricorn, thereby reversing the seasons in the two zones.*

*In March and September, the sun's rays reach both poles. It is then spring in the Northern, and fall in the Southern Hemisphere.*

*The seasons of polar regions are practically day and night; the former being the summer, and the latter, the winter season.*

*The climate of the Torrid zone is that of perpetual summer, the seasons being the wet and the dry.*

*Lines passing through localities having the same temperature are called isotherms; and the zones they bound, isothermal zones.*

*In temperate zones, isotherms bend northward towards the western coasts of continents.*

*Forests and growing shrubbery preserve the moisture of the soil by causing much of the rain to soak into the ground.*

*The destruction of forests is frequently followed by disastrous floods and a decrease of moisture in the soil.*

# CHAPTER XIX.

## THE DISTRIBUTION OF LIFE.

Tropical Vegetation.

1. **Plants.**—Plants were among the earliest forms of life to appear on the Earth, and though nearly all of the first species are now extinct, they have been replaced, not only by similar species, but also by higher ones. Unlike most other forms of life, plants take their food directly from the soil, the air, and the water.[1]

2. **Composition.**—Plants consist of from three-fourths to nine-tenths water. Carbon, nitrogen, hydrogen, oxygen, potassium, lime, phosphorus, and silicon, in various forms and proportions, compose the remaining parts.[2]

3. **The skeleton** of the plant is always carbon. Silicon, when present, forms a hard external varnish, such as is found on the outer part of the bamboo, corn-stalk, wheat-straw, etc. It gives strength and protection to the stalk.

4. **Various salts** of potassium and lime are carried through the plant by its sap, and some of them are finally deposited in the seed. All except the lowest forms contain a green coloring matter called *chlorophyl* (*klo'ro-fĭl*).

[1] A few of the lower forms of animal life resemble plants, in taking their food by absorption, but the character of the food is different.

[2] Other and rarer elements, such as iodine, bromine, lithium, etc., are found in certain plants.

View on the Amazon. Palms.

5. **The seed** consists mainly of starch, with perhaps more or less of oil. The seed-germ is usually rich in vegetable albumen, and contains phosphorus combined with lime and potassium. So important is the phosphorus, that without it, the seed will not mature. It is chiefly the lack of phosphorus that causes land to "wear out."

6. **Heat** is likewise necessary to the development of plants. But few plants will germinate if the temperature be below 40° F., while many perish when the temperature falls below 60° F. for any length of time.

7. **All of the higher plants** are more or less dependent upon light for germination and growth. Certain fungi, and plants having no chlorophyl, however, grow best in the dark.

8. **Agents of Distribution.**—In the distribution of plant-life over large areas and in the perpetuation of many species, certain agents are constantly at work. Of these agents the most important are winds, running water, man, animals, and insects.

9. **Many seeds**, such as the dandelion and the thistle, are covered with a soft furze, which enables them to be carried to a great distance by even the gentlest breeze.

10. **The maple** and a few other plants have winged seeds, which are carried to a great distance by a strong wind. Many seeds, such as the chestnut and the burr-clover, are enveloped in a cover armed with thorns or spikes which tend to prevent their destruction by animals, and thereby increase their chances of perpetuation.

11. **The juicy and rich-colored pulp** covering many seeds, such as those of our common orchard fruit, attracts the attention of birds and other animals. These eat the fruit and scatter the seeds far and wide.

12. Nearly all seeds are provided with shells or coverings, by means of which they float upon the water. Many oak, beech, and willow groves have grown from seeds scattered in this manner.

13. **Insects** aid in the distribution of a few plants, as the fig, yucca, and clover, by fertilizing the flowers. In each case, the insect, while taking the honey-dew from the flower, smears the pistil with the pollen of the flower.[1]

14. **Birds** convey in their crops, the seeds of many species of plants to distant localities—even across the ocean. Most of the coral islands have received valuable additions to their flora in this manner.

[1] The flowers of our common clover are fertilized by the humblebee. It is a well-known fact that clover will not thrive well in localities where the humblebee is not found.

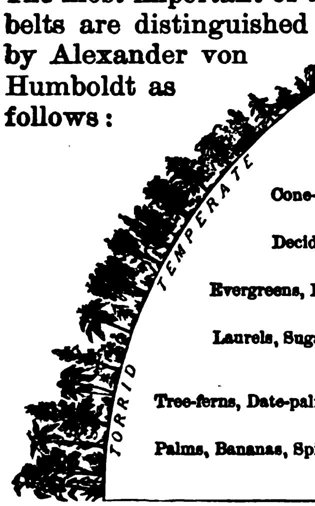
15. By far the greatest distribution of plant-life has been brought about by **man.** Through his agency all of the food-producing plants have been scattered over the world.

16. **Effect of Climate.**—All countries differ in the plants which their soils produce, and these differences are owing to various conditions of heat, light, and moisture.

17. **The warm and moist climate** of the Torrid zone favors the most luxuriant growth of plants. The Colorado desert, equally warm but destitute of moisture, produces nothing but a few species of agave (*ă-gā've*) and cactus.

18. **The tundras** of the arctic plains suffer no lack of moisture; but the low temperature, seldom exceeding 35° F., forbids the growth of anything except a few lichens.

19. Between these extremes there are several well-marked belts or zones of vegetation. These belts correspond, however, with isothermal lines rather than with parallels of latitude. The most important of these belts are distinguished by Alexander von Humboldt as follows:




| | LATITUDE. | TEMPERATURE. |
|---|---|---|
| Mosses, . . . | Polar | Below 32° F. |
| Shrubs, Birches, . . . . | 60 to 72 | 32° to 45° |
| Cone-bearing Trees, Berries, Potatoes, | 45 to 65 | 40° to 50° |
| Deciduous Trees, Grain, Tea, . . . | 40 to 48 | 45° to 60° |
| Evergreens, Rice, Vines, Oranges, Olives, . | 30 to 45 | 55° to 70° |
| Laurels, Sugar-cane, Cotton, . . . . . . | 20 to 32 | 68° to 75° |
| Tree-ferns, Date-palms, Coffee, Cocoa, . . . . . | 15 to 25 | 73° to 78° |
| Palms, Bananas, Spices, . . . . . . . . . . | Equatorial | Above 78° |

Chart showing that the luxuriance of vegetation diminishes toward the poles. Trees and productions of the zones.

20. **Food-Plants.**—The most important and the most widely spread of all plants are the grasses. They are plentiful in nearly every part of the world, excepting the polar regions. They also include nearly all of the grains and many of the palms.

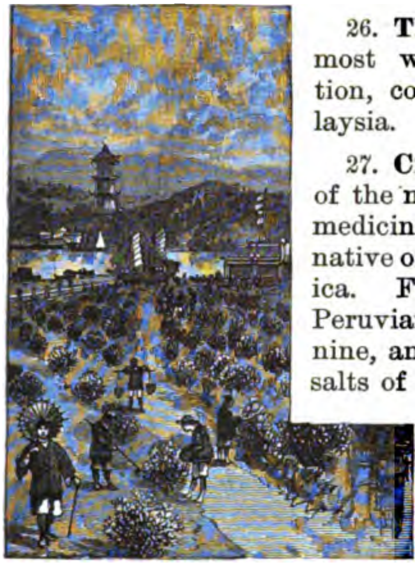
21. **Wheat,** oats, rice, barley, and rye, are native to Asia, and were carried from thence into the new world. It is asserted that the grains have never grown in a wild state.

22. **Maize,** or Indian corn, is indigenous to the new world. In importance, it ranks next to wheat. The potato, the yam, and the tobacco-plant are likewise native to America. All of these have been successfully introduced into the old world.

23. **Sugar-cane,** originally from China, or perhaps India, is now cultivated in nearly every warm country in the world. The consumption of sugar is rapidly increasing. It is produced in the West Indies, the southern United States, the Sandwich Islands, and Brazil. Excellent sugar is made also from the juice of the beet.

24. **Tea and Coffee.**—The cultivation of the tea-plant is confined to China, Japan, and Farther India. There are two varieties of the plant; but from the same kind of leaf, either black tea or green tea is produced, according to the method of curing.

25. **Coffee,** the seed of the fruit borne by the coffee-tree, is a native of Abyssinia. The Mocha coffee of Arabia is considered the choicest. Brazil, the West Indies, Central America, and Java export large quantities. Most of the coffee used in the United States comes from Brazil.

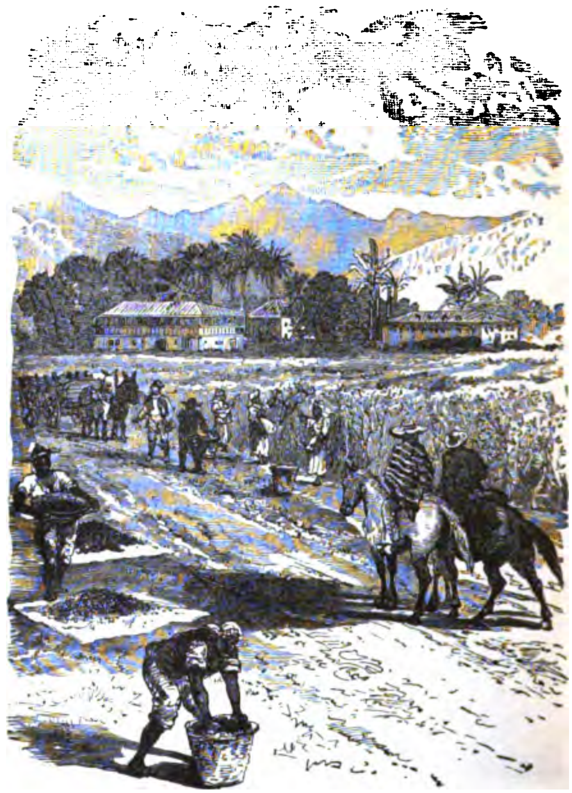


A Tea Plantation in China.

26. **The spices,** almost without exception, come from Malaysia.

27. **Cinchona,** one of the most important medicinal plants, is a native of South America. From this tree, Peruvian bark, quinine, and the various salts of cinchona (*sin-ko'na*) are obtained.

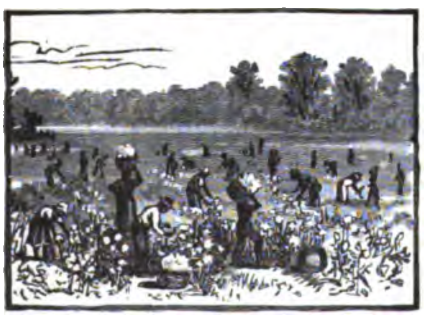
28. Opium, the gum exuding from the seed-pod of the poppy, is produced in China, India, and various other parts of southern Asia.



A Coffee Plantation in Brazil.

29. **In the tropical regions,** the food-plants are comprised in a very few species. The palms yield the date, cocoa, and sago. The cassava furnishes tapioca, the principal food of the South American Indians, while the bread-fruit tree yields the subsistence of the Polynesian. The absence of food-plants from a country forms an insurmountable barrier to the existence of animal life.

30. **Starch and gluten** constitute the elements of nutrition in nearly all of the foregoing food-plants. Their seeds are always very rich in phosphorus, oil, and other substances required by the animal body.



A Cotton Plantation.

31. **Textile Fiber Plants.**—The plants producing cloths and textile fabrics are as widely cultivated as the food-plants. Cotton, the chief of these, is thought to be a native of India, but it is probable that its use precedes our historical knowledge of it. From the United States, China, and India, the greatest quantities are obtained, but it is cultivated in nearly all warm countries.

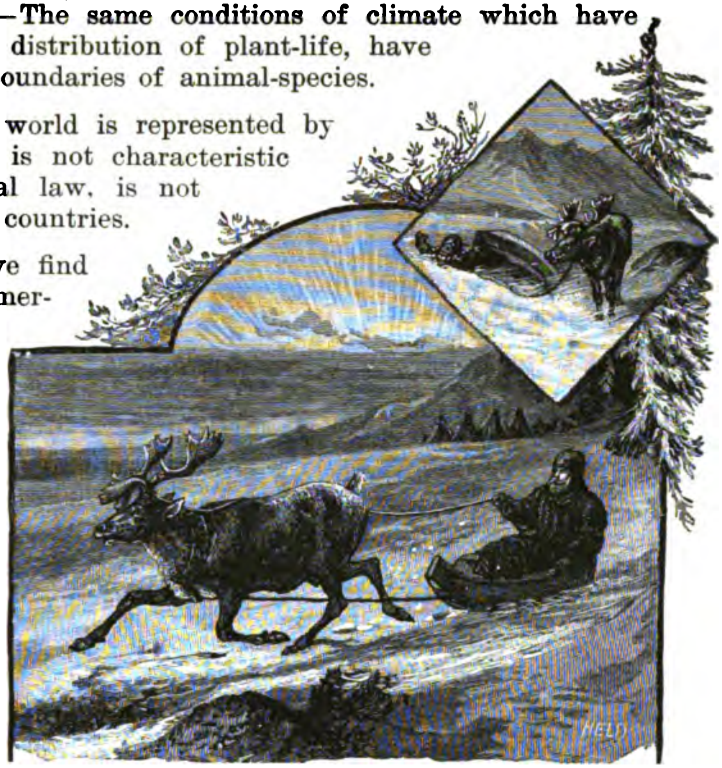
32. **Flax,** a plant native to Europe, produces the beautiful white fibre of linen cloth. It is now widely cultivated in the United States and other countries. Hemp, ramee, and jute are native to India; their fiber is much used for coarser cloth and for cordage. From India, their cultivation has been introduced into Europe and America.

33. **Distribution of Animals.**—The same conditions of climate which have been so powerful in controlling the distribution of plant-life, have been equally powerful in fixing the boundaries of animal-species.

34. Each grand division of the world is represented by some particular form of life which is not characteristic elsewhere, and which, as a general law, is not adapted to life and growth in other countries.

35. Thus, in Europe and Asia, we find the cud-chewing animals; in North America, there are the birds of passage; South America is distinguished for its toothless species; while the marsupials or pouched animals are confined almost exclusively to the Australian continent.

36. We find, also, that in past ages many species of animals have disappeared, and that their places have been taken by others. In nearly every instance, the succeeding types have differed slightly from those preceding. Nearly always, the later types have been the superior.



Reindeer.

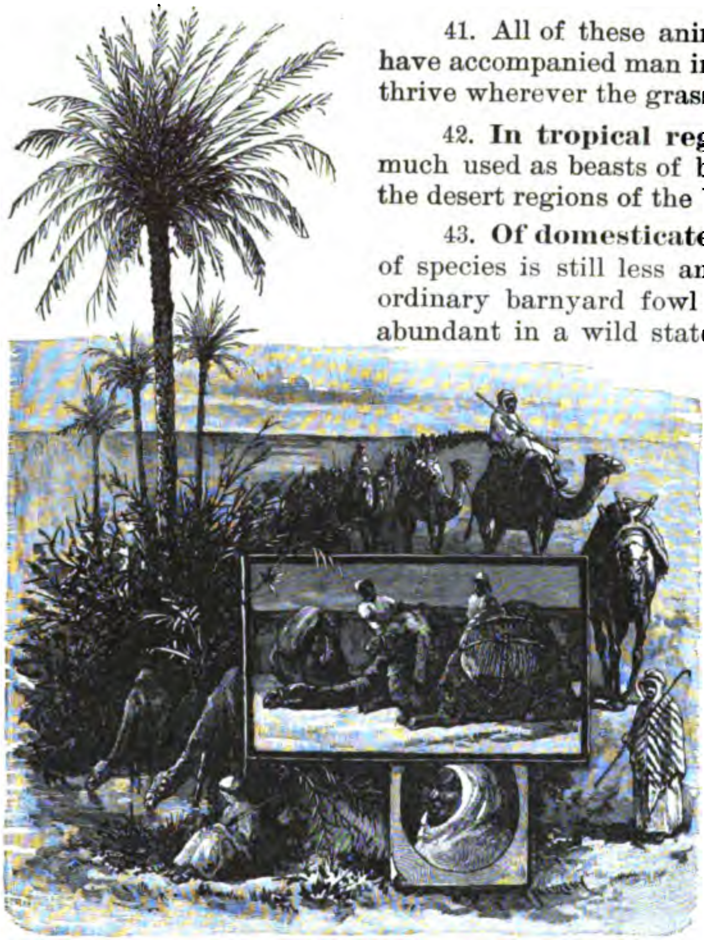
Lassoing Wild Horses.

37. Of the many thousand species of animals existing on the Earth, but a very few are of use either as food or as beasts of burden.

38. **In the northern regions,** the reindeer of the old world, in this respect, stands first. In the western hemisphere, his place as a beast of burden is partly supplied by the Esquimau dog.

39. Seal blubber and fish furnish about the only sustenance to the natives of the northern lands of the American continent, many of whom know no other food.

40. **In the Temperate zone,** the horse, ox, hog, and sheep are the most important domestic animals. These have been distributed by the agency of man throughout the habitable parts of the globe.



Camel Caravan.

41. All of these animals are probably natives of Asia, and have accompanied man in his migrations. They are hardy, and thrive wherever the grasses are found.

42. **In tropical regions,** the camel and the elephant are much used as beasts of burden. The former has been used in the desert regions of the United States, in this capacity.

43. **Of domesticated birds** used by mankind, the number of species is still less and comprises scarcely any except the ordinary barnyard fowl and the ostrich. Most of these are abundant in a wild state.

44. **The fur-bearing animals** are wild, and are natives of the colder regions. They comprise the fur seal, beaver, otter, sable, stone marten, ermine, and mink. The fur seal is the most important.

45. **The bee and the silk-worm** have been distributed far and wide, through the agency of man. So important are these insects, that throughout the world, they are protected by national laws. In China, Japan, France, and Italy, the culture of the silk-worm ranks among the most important industries.

46. **The two hemispheres** present many points of difference, in respect to their zoölogy. The lion, the tiger, the leopard, and the hyena are unknown on the American continent. Here, the tiger is represented by the panther, the puma, and the wild cat. The carnivorous animals of the new world are fewer in species and smaller than those of the old.

47. **The elephant** is found in the tropical regions of Asia and Africa, but the species of the two continents differ, in many respects. This animal has no representative in the Western Hemisphere.

48. **The rhinoceros** is also found in Asia and Africa, but does not exist elsewhere. The hippopotamus is confined to a limited part of Africa, being found in the region of the Nile river only.

49. **The walrus** and the **polar bear** are found in the cold regions of both hemispheres. The former is amphibious, and its distribution is limited by temperature only. The polar bear is not only an expert swimmer, but also an inhabitant of floating ice packs. Hence its wide distribution in these regions.

50. Several species of bear are found in the mountainous regions of the North Temperate zone. Those of the two hemispheres differ but slightly. The grizzly bear is found in the Rocky mountains only ; the black bear is distributed over North America.

51. **The dog** and the wolf are found in about the same latitudes throughout the world. There are many species, but they do not differ much from one another.

52. **Reptiles** and snakes are most numerous in the moist tropical regions, but gradually disappear in the higher latitudes. Their species in both hemispheres are similar.

53. **Monkeys** are also abundant in all tropical regions of the world. There are many species of them, but those of the Eastern and Western Hemispheres are very distinct.

54. Those of the American continent are small and more closely resemble quadrupeds. With the exception of one species they possess tails. The monkeys of the old world are larger, and usually tailless.

The Monkey-bridge.

The Rhinoceros.

55. **The zoology of Australia** is unlike that of any other part of the world. But few species of animals existing in other parts of the world are found here, and these, for the greater part, are birds. The animals are generally marsupials or pouched animals.

56. **The eagle,** hawk, owl, parrot, and Australian ostrich do not differ greatly from those of other continents. The opossum resembles that of North America in structure and habits.

57. **The kangaroo,** of which there are many species, is not found in any other part of the world. The ornithorhyncus, an animal having the body of an otter with a head like that of a duck, is also peculiar to Australia.

The Black Bear.

58. The preceding **paragraphs** serve to show that **climatic regions** constitute the centers from which the various forms of animal and plant life have spread.

59. The territories frequently overlap one another, but each region is still a strongly marked center, and wherever its life-forms have changed, the change is due usually to the agency of man.

60. Those changes in animal life and habits which have been wrought by the agency of man, constitute the best of proofs that the laws of nature operate not only in a similar manner, but also on a stupendous scale.

61. So exacting are these laws, that neither evasion nor disobedience is tolerated. A failure to conform to them is followed by the death of the individual or even the extinction of the whole species.

62. **The Human Race.**—The population of the Earth is estimated at about 1,461,000,000 people, who occupy every part of its land surface except the polar regions. Their distribution is shown in the following table:

| GRAND DIVISIONS. | POPULATI'N. | POP. TO 1 SQ. M |
|---|---|---|
| **Asia** | 835,000,000 | 47 |
| **Europe** | 318,000,000 | 86 |
| **Africa** | 206,000,000 | 16 |
| **North America** | 73,000,000 | 8 |
| **South America** | 25,000,000 | 4 |
| **Australia & Oceanica** | 4,000,000 | 1 |

63. For convenience, they are grouped into five races, the Caucasian, Mongolian, Black, Red, and Malay.

The Lion.

64. The Malays and the American Indians are by many considered as separate races; by others they are classed among the Mongolians, to whom they bear a strong resemblance in structure and in language.[1]

The Caucasian Race; Egyptian, Arab, Abyssinian, European.

65. **The Mongolian** is the yellow race. The distinctive features are: black eyes, straight black hair, a flat nose, and usually a yellow skin.

66. This race includes the Chinese, Japanese, Tartars, Burmese, Siamese, and Turks, of Asia; the Lapps, Finns, and Magyars (*mŏd'jors*), of Europe; and the Esquimaux, of America. The Turks and Circassians have white skins.

67. **The Caucasians** are more widely diffused than any other race. They are distinguished by a skin varying from white to dusky brown, black or brown hair, and gray or brown eyes. The most noticeable characteristic is the high forehead and oval skull.

68. The Caucasian race has colonized Europe, America, and northern Africa. This race exists in Hindostan and portions of Asia, where it seems to have originated.

69. **The Malays** bear a close resemblance to the Mongols, having, however, a brown skin. They inhabit most of the islands of Malaysia.

70. **The Negro** or black race is distinguished by a black skin, black eyes, black, woolly hair, thick, protruding lips, high cheek bones, and a broad, flat nose.

71. The Negroes are native to central Africa and a chain of islands of which New Guinea is the largest. About six million people of this race are found in the United States and the West Indies.

Mongolian or Yellow Race; Esquimaux and Chinese.

72. **The American Indians,** or copper-colored race, are also related to the Mongolians. Those of the Pacific coast of North America are clearly of Mongolian origin. They are distinguished by a skin varying from reddish to dusky brown, black eyes and hair, and high cheek bones.

73. Indians formerly occupied the most of the American continent. In North America, they are rapidly disappearing. In South America, they have intermarried with Caucasian colonists, and are becoming a powerful people.

[1] This classification is both unsatisfactory and unscientific, but no system meeting with general adoption has yet been proposed. With the present system, the inhabitants of Caucasia are made the type of the race. Late investigations have shown that these people are of Mongolian descent.

The Malay Race; Sandwich Islanders and New Zealanders.

74. The physical difference in the people composing the human race is wide. By those who believe in the common origin of the race, it is asserted that these differences are due to climate, food, and manner of living.

75. **Causes of Difference in Development.**—The general condition of a people depends much upon their manner of living, and this in turn is governed by climate. A people living in a country where their wants are supplied without exertion, are not likely to become a powerful nation.

76. On the contrary, if a rigorous climate requires the skill of body and brain to obtain those things necessary to sustain life, such a people are apt, in the course of generations, to become powerful.

77. **It is the struggle for existence** that develops not only the body, but the mind of man as well; and it is this struggle that has caused mankind to associate in clans and to organize institutions for mutual protection and support.

78. **In the North Temperate zone,** the conditions are best suited to physical and intellectual development. Here the battle with hunger has awakened man's dormant powers.

79. To insure his existence, he is compelled to exercise both hand and mind. But even these are not enough, and the subjugated forces of nature perform the tasks to which his own strength is unequal.

80. No exact date can be assigned to the first appearance of man upon the Earth. His early history is unwritten and unknown. The geological evidences are too meager to furnish any satisfactory clue to his history, socially or intellectually.

81. They show, however, that primeval man dwelt in caves, that he followed the chase, that he used weapons, that he wore rude ornaments, and that he had learned the use of fire.

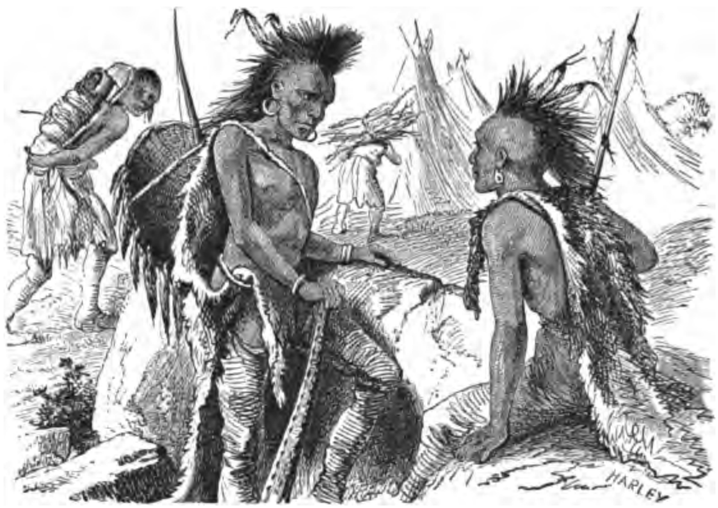
82. **Knowing the use of fire,** his civilization was a certainty, and henceforth, guided by the hand of an All-wise Creator, his path lay in the way of light.

The Black Race.

83. With the appearance of man, the long succession of steps in the creation of life-forms seems to have ceased. His coming was the culminating act of creation.

84. Physical development had reached its highest plane, and intellectual development began its sway. The reign of matter ended, and that of mind began.

85. The Earth was made as a dwelling-place for man. Its day and night, land and water, air and clouds, seed-time and harvest, forests and mines,—all contribute to his comfort and well-being.



American Indians, or Red Race.

## WHAT HAS BEEN TAUGHT IN CHAPTER XIX.

*The food of plants consists of water, carbon, hydrogen, oxygen, silicon, potassium, lime, and phosphorus.*

*Variations of these elements are the cause of great diversity in the distribution of plants.*

*The distribution of plants is accomplished by winds, water, birds, insects, and man.*

*The chief food-plants belong to the palms and the grasses. They are native to Asia, and their distribution has accompanied the migrations of man.*

*The laws governing the distribution of plants also govern the distribution of animals.*

*Compared with the number of plants, but few species of animals are serviceable to man.*

*In northern latitudes, the reindeer ranks first as a beast of burden and a source of food.*

*In the Temperate zones, the horse, ox, sheep, and hog, all natives of the old world, are valuable sources of food and clothing.*

*The silk-worm and the honey-bee have been distributed over the world by the agency of man.*

*The elephant is a native of both Africa and Asia, the two species being distinct, and having no representatives on the American continent.*

*The hippopotamus is confined to a small portion of Africa.*

*The bear, walrus, and wolf are found in the northern belt throughout the world.*

*The monkeys of the old world are larger, and more closely resemble the human species than those of the new.*

*Each climatic region is a center from which animals peculiar to that region have radiated.*

*The population of the Earth, consisting of one and a half billion people, are classified as Caucasian, Mongolian, Black, Red, and Malay.*

*The Mongolian, or yellow race, inhabits parts of Asia, Europe, and America.*

*The Caucasian race has colonized Europe, America, and Africa, and occupies the southern part of Asia.*

*The Negro, or black race, inhabits central Africa, and a part of the Malaysian archipelago.*

*The Malays (considered by some authorities, a division of the Mongolian race) are confined to the Malay Peninsula, Malaysia, and Polynesia.*

*The American Indians are found only in the American continent.*

*The races differ, not only in color of skin, but also in the shape of skull, color of hair and eyes, and in language.*

*In the North Temperate zone, the conditions are most favorable to the development of man.*

# CHAPTER XX.

## THE DISTRIBUTION OF MINERALS.


1. The geographical distribution of minerals is not only closely connected with the establishment of manufacturing and other industries, but it has also had much to do with the development and civilization of mankind.

2. The earliest history of the human race is associated with implements and tools made of mineral substances; the earliest written history begins with the use of metals.

3. The chief mineral deposits are in the mountains and highlands. Coal, however, is found, to a great extent, in lowlands. The mineral resources considered in this chapter are metals and their ores, besides fuel, building stones, and gems.

4. **Iron.**—Iron is more closely connected with the civilization of the human race than is any other substance found in the Earth. It is the most widely diffused and, at the same time, the most abundant of all the metals.

5. The ores of iron are abundant in the mountainous regions of nearly every part of the world. In the United States, the Appalachian mountain system is the center of production, although it is widely distributed throughout both the eastern and the western highlands.

6. Steel, which is prepared from iron, is fast supplanting it for most purposes. The value of the iron and steel manufactures in the United States exceeds 300,000,000 dollars yearly. The most abundant ore of iron is known as *hematite.*

7. **Copper.**—Copper preceded all other metals used by man. It is found in nearly all highland regions. In the United States, the largest deposits are found in the Pacific Highlands and in the vicinity of Lake Superior. The chief ores from which it is obtained are *malachite,* a carbonate, and *copper glance,* a sulphide.

8. **Tin.**—Tin is found in but few localities, the chief sources being Cornwall, England, the island of Banca, Malacca, and Australia. There are also valuable mines in California and Mexico. The total yearly production in the world is about 34,000 tons.

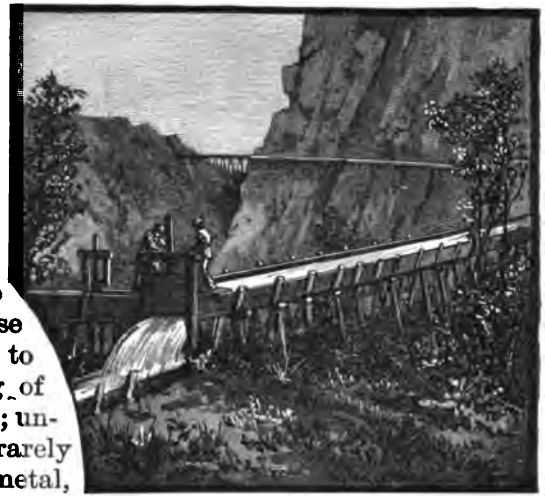
9. **Zinc.**—This metal is abundant in many parts of Europe and America. The mines of Silesia and Freiberg, in Europe, and those of Pennsylvania and New Jersey are the most productive.

10. **Lead.**—The lead mines of the world are found both in plains and highlands. The ore from which lead is extracted is *galena,* a combination of sulphur and lead.

11. Lead is found in nearly every country of Europe and Asia. The most extensive deposits of the United States are in Colorado, Nevada, and Arizona. There are, also, very productive mines in Missouri, Wisconsin, and Illinois.

A Silver Mine and Mill.

12. **Silver** is about as widely disseminated as gold, but is found in much larger quantities. Like gold, its use dates back to the beginning of written history; unlike gold, it is rarely found as a metal, and therefore is not found in alluvial soils.



Mining Flumes for Conducting Water.

13. Silver occurs in nearly every mountain or highland system in the world. It is usually combined with either sulphur (*silver glance*) or chlorine (*horn silver*); it is always associated with lead, and frequently with copper, antimony, and arsenic.

14. In the United States, the chief sources are the mines of Colorado, Nevada, Utah, Montana, and Arizona. The mines of the Comstock lode in Nevada for many years produced nearly as much as the combined amount of all the other mines of the world.

15. **Gold.**—Gold is one of the most widely, although sparingly, disseminated metals. It is found in all soils, granitic rocks, and in sea water. The chief deposits, however, are in the quartz veins and the ancient river beds of the Pacific Highlands and Georgia. The African and the Australian gold fields have also produced much gold.

16. Gold is found in a metallic state, but it is never pure, being alloyed usually with silver and platinum. The luster of gold, its malleability, its ductility, and its resistance to the strongest acids, give it a high intrinsic value.

17. There are many reasons to believe that the gold and silver found in quartz veins were dissolved from igneous rocks by hot water. Water under great pressure may be heated several hundred degrees above the boiling point, and it will then dissolve many mineral substances which it would not otherwise.

18. As the hot water is pressed upward through the crevices in the rocks, it becomes cooler and can no longer hold these substances in solution. The silica is deposited on the sides of the crevices as quartz, and with it the various metallic substances of which metallic iron, copper, gold, and silver are the principal. Finally, the crevice is entirely filled, and a **quartz vein** is formed.

19. **Nickel.**—Nickel, which until lately has been considered one of the rarer metals, is now one of the most extensively used. It is as hard and infusible as iron, does not blacken nor corrode, and its luster surpasses that of silver.

20. This metal has almost entirely superseded silver for plating purposes. It is found in Sweden, Spain, and Germany. The mines of Pennsylvania are the chief source in the United States. Those of Lovelock, Nevada, are extensive.

21. **Quicksilver.**—This metal, also called mercury, is the only one existing as a liquid at ordinary temperatures. There are but few productive mines known. Those of Almaden, Spain, and New Almaden, California, supply four-fifths of the amount used. *Cinnabar*, a sulphide, is the ore from which it is usually obtained.

22. **Other Metals.**—Many of the metals least known are the most widely distributed. Such, for instance, are sodium, the base of common salt; potassium, the base of potash salts; calcium, the base of lime.

23. Alumin'ium, the base of common clay, is a valuable metal, but the cost of extracting it has prevented its use. Platinum, iridium, and osmium are usually associated with gold. Platinum is valuable on account of its infusibility.

24. **Precious Stones.**—Of the precious stones, the diamond has for many centuries been the most admired and generally the costliest. The diamond is pure carbon in a crystalline form, and the hardest mineral known. The alluvial deposits of South Africa and Brazil have furnished the greatest number.

25. **Rubies and sapphires** are oxides of aluminium. The color is due to the presence of other mineral substances. The red variety is called the ruby, the blue is known as sapphire. Faultless stones rank next in value to the diamond.

26. **Emerald or beryl,** is also a gem of which aluminium is the base. The beautiful green color is due to a small amount of chromium oxide. Emeralds, rubies, and garnets are found in granite rocks and slate.

27. **Topaz** is also a gem having an aluminium base. It varies much in color, but the wine-colored topaz of Saxony is the most highly prized. The mountains of Brazil and Siberia furnish the greatest supply.

28. **Quartz,** frequently called *silica,* furnishes by far the largest variety of gems. Of these the **opal** is the most valuable. It differs from common quartz in containing water of crystallization.

29. **Amethyst** is quartz colored pink or purple by traces of manganese oxide. **Agate** and **chalcedony** (*kal-sed'o-ny*) are quartz with variously-colored layers. **Carnelian** and **sar'donyx** are red, semi-transparent varieties of quartz colored with oxide of iron.

30. **Jasper** and **bloodstone** are opaque varieties of quartz mottled with salts of iron, nickel, and manganese. All of these are abundant in mountainous regions. **Onyx** is a variety of quartz, having alternate black and white bands.

31. **Turquoise** (*tur-koiz'*), **malachite** (*mal'a-kite*), and **chrys'ocolla** are minerals having a copper base. The first is obtained in Persia and New Mexico, the last two in the Ural mountains and the Pacific Highlands.

32. **Coal.**—Coal, although of vegetable origin, is classed among the minerals. In form and position, the coal-beds do not differ from the stratified rocks of which they are an example.

33. Like other stratified rocks, the coal-beds have been formed in the presence of water. But unlike them, the coal-seams consist of layers of half decomposed vegetable matter, such as twigs, leaves, rootlets, and the trunks and roots of trees, instead of accumulations of sediment.

34. There are two ways in which most of the vegetable matter forming the coal-beds accumulated. It may have grown in place, or it may have been deposited at the mouths of rivers, having been carried there by the river itself.

35. In the first case, what are now coal-beds were formerly immense **peat swamps.** In fact, there are peat swamps in various parts of the world at the present time, in which the half-decomposed vegetable matter that has accumulated in the swamp, is undergoing the first steps of its change to coal.

36. Such swamps are common in all parts of the world, especially in northern countries. One-tenth of the area of Ireland is covered with them. They are common in parts of France, Switzerland, the New England states, and the Dominion of Canada.

37. Peat may be any vegetable substance; but it usually applies to the remains of certain species of mosses which, dying at one end, retain life and grow at the other. Frequently, accumulations are thirty or forty feet in thickness.

38. **The next step** in coal-making was the sinking of the peat swamp or other accumulations of vegetable matter, below the sea-level. After this had occurred, the water gradually covered it with sand and mud, burying it many feet deep.

39. **The great weight** of the sediment spread over the swamp pressed it into a flat layer or seam; this pressure generated heat, and the partial decomposition of the vegetable matter generated still more. In the course of time, the combined action of heat and moisture changed the substance to coal.[1]

40. Often the same processes of accumulation, submergence, and partial combustion have taken place again and again, until, in some localities, there are more than one hundred distinct seams of coal. In the United States, the coal-forming process did not cease until the upheaval of the Appalachian mountains lifted the coal-beds high above the sea-level.

41. **The varieties of coal** differ much in appearance and composition. They include mineral oil (petroleum), mineral pitch (asphaltum), lignite, brown coal, cannel[2] coal (and shales), jet, bituminous or soft coal, anthracite or stone coal, and graphite. The latter is an infusible form of carbon, and is classed along with coal on account of its origin.

42. It is thought that the difference in varieties of coal is owing to varying degrees of pressure and heat. Whenever the pressure was great and the temperature high, the volatile matter was driven off and thereby converted the bituminous and fat coal into anthracite.

43. In older rocks, there is evidence that the pressure has been much greater and the temperature higher. As a result, the coal or carbon is found in the form of **graphite,** the so-called black lead of commerce.

44. **Distribution.**—Coal is found usually in the rocks of the Carboniferous Age (see p. 16), of which it is the chief feature. There are also large deposits of coal in the rocks of the Tertiary Age, which are usually called **cretaceous coals.** Coal fields are more or less abundant wherever the rocks of these geological ages reach to the surface.

45. The total area of these fields exceeds 200,000 square miles. Of this area, 150,000 square miles are in the United States, 18,000 square miles are in the Dominion of Canada, and 12,000 square miles, in Great Britain. The other fields are chiefly in Spain, France, Germany, and Belgium.

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[1] Coal has been formed artificially by subjecting wet sawdust to pressure and heat.

[2] A corruption of *candle.* Bituminous, cannel, and other fat coals also contain much oxygen. Brown coal and lignite are imperfectly formed coals. Often coal of this kind contains stumps and trunks of trees, sometimes unaltered, but quite frequently partly converted into coal.


Salt Mines of Wieliczka (*we-litch'ka*), near Cracow, Austria.

46. The coal fields of North America comprise the border fields of Rhode Island and Nova Scotia; the Alleghany fields of the Appalachian Highlands; the interior fields of Michigan, Illinois, Missouri, and Iowa; and the Arctic fields of Melville island and vicinity. Tertiary coal is abundant on the Pacific coast.

47. **Petroleum.**—Mineral oil or petroleum is also a product of vegetable matter. The process of formation is similar to that of the coal deposits. It is probable that mineral oil has been formed only when the decaying matter was deposited in salt marshes.

48. The best known oil regions are those of Pennsylvania and Canada. The oil fields of southern California, however, are thought to be the most extensive at present known.

49. **Building Stones.**—The building stones most commonly used are granites, sandstones, and limestones. Each class of these rocks contains many varieties; but only those which are strong and do not crumble by exposure, are useful.

50. **Granite** is in many respects the best of all building stone. Much of the so-called granite is either gneiss (*nice*) or syenite (see p. 14). Granitic rocks are common in nearly all mountain ranges, having been thrust upward through the stratified rock.

51. Granite is usually of a grayish-white color, but syenitic varieties are often very dark. There are immense deposits in New Hampshire and Vermont. The red granite of the Rocky mountains is highly prized.

52. **Sandstones** are just what their name indicates—rock composed of sand. There must be some cement (*sĕm'ent*), however, to unite the grains of sand into rock.

53. The cement is usually either iron oxide or lime. The latter forms a white or gray sandstone, while the former are usually reddish-brown. The durability of this stone depends on the proportion of the cement.

54. This variety of building stone is found in all continental divisions of land, being most common in the foot-hills of mountain ranges, especially on that mountain slope which faces the sea. "Brown stone" and "old red" sandstone are well known varieties.

55. **Limestone** is a stratified rock, and therefore water-formed. Of the three commonest forms, chalk, gray limestone, and marble, the latter two only are serviceable as building stones. The gray limestones are found chiefly in old marine plains. There are large deposits in the Mississippi valley, where the rock is known as "Athens marble," "Niagara limestone," "gray stone," etc.

56. **Marble** is also a stratified rock, which does not differ in composition from the gray limestones. In appearance, it is commonly much whiter, although it is often beautifully streaked with gray, or mottled with variously colored spots.

57. Marble is a metamorphic limestone—that is, common limestone changed by pressure, heat, and moisture, to crystalline rock. It is in mountain ranges only, where these conditions have been fulfilled, and here are most of the valuable deposits of marble.

58. The choicest varieties of marble are found in the province of Carrara, in Italy. Black, or Portoro marble, also comes from Italy. Much ornamental marble is obtained in Vermont, Tennessee, Maryland, and the Rocky mountains.

59. **Rock salt** is found in nearly every country in the world, and in the rocks of all geological periods. The salt deposits are usually the beds of former lagoons, cut off from the sea by wave-formed sand bars.

60. The salt mines near Cracow have been worked for more than 700 years. In the United States, the chief salt deposits are those of New York, Michigan, and Louisiana.

## WHAT HAS BEEN TAUGHT IN CHAPTER XX.

***Metals and minerals are closely connected with the civilization of the human race, and in many cases, precede its written history.***

***Excepting coal, most of the metals and minerals useful to man are found in highlands.***

***Copper and iron are the oldest and most useful of all metals. These metals are extracted from ores.***

***Tin, lead, zinc, and quicksilver are of secondary importance. Except the latter, they are occasionally found in lowland plains.***

***Gold, silver, and nickel are widely but sparingly disseminated. They are usually found in veins, where they have been deposited by water.***

***Sodium, potassium, calcium, and aluminium are valuable for their various salts, such as common salt, potash, lime, clay, etc.***

***The diamond is composed of pure carbon, and is the most highly prized of gems. It is found in Brazil and South Africa.***

***The ruby, sapphire, emerald, and topaz are gems having aluminium as a base. These gems are usually found in granitic rocks.***

***Amethyst, opal, chalcedony, sardonyx, agate, and jasper are varieties of quartz, colored with oxides of iron or manganese.***

***The process of coal formation consisted of:—1st, the accumulation of vegetable matter in peat bogs or in drifts; 2nd, its burial under the sea; 3rd, its change to coal by the pressure of overlying sediment.***

***The principal varieties of coal are (graphite), anthracite, bituminous, cannel, and lignite; also the hydrocarbons, asphaltum, and petroleum.***

***The coal fields of the United States have an area about four times as great as that of all of the other coal fields in the world.***

***Petroleum is derived from vegetable matter, and has been formed in the presence of salt water. The chief deposits of the United States are found in Pennsylvania and California.***

***The principal building stones are comprised among the granitic rocks, sandstones, and limestones.***

***Granite is found in nearly all mountain ranges.***

***Sandstone is formed from sand cemented into a compact mass by lime or by oxide of iron. The former varieties are white or light colored: the latter are brown.***

***Limestone is an aqueous rock, and includes chalk, marble, and common gray limestone.***

***Gray limestones are most abundant in old marine plains. There are immense deposits in the Mississippi valley.***

***Marble is a metamorphic limestone, and is found usually in mountains, where the conditions are present for its formation.***

***Rock salt is usually found in old lake beds cut off from the sea. There are many such deposits, and they are found in all parts of the world, as well as in rocks of nearly every geological age.***


Compiled from notes and maps made by Major Greely.

# APPENDIX.

## THE ORTHOGRAPHY, BERING, NOT BEHRING.

TO THE AUTHOR OF MONTEITH'S GEOGRAPHIES:—

The orthography, *Bering*, is used in the Coast Survey and other government publications. Commander IVAN IVANOVITCH BERING uniformly spelled his name *Bering*, as do his descendants now living in Denmark. The erroneous form, *Behring*, was first introduced in the second decade of the present century. Special students of Alaska steadily adhere to the correct form, *Bering*, and I take occasion to congratulate you on the attempt to spread the correct form before a large and increasing audience.

J. E. HILGARD,
*Supt. U. S. Coast and Geodetic Survey.*

WASHINGTON, D. C., *Jan. 26, 1885.*

**Lieut. Schwatka,** an officer in the United States Army, led an expedition in 1879 and 1880, in search of information concerning the fate of Sir John Franklin, a celebrated Arctic explorer who set out from England in 1845, to find a northwest passage or commercial route from that country to Asia, but who never returned.

Expeditions had, at various times, been sent in search of him, but it was not until Schwatka accomplished his work that all the members of the Franklin party were known to have perished. Schwatka's is the longest sledge journey ever made,—over 3,000 miles. His sledges were drawn by 44 dogs.

Schwatka met a native chief who had seen either the *Erebus* or the *Terror*, Franklin's ships; and from him he learned that the ships were abandoned and sunk, and that some spoons, knives, cooking utensils, books, and records had been taken by the natives. Not knowing the value or use of the books and records, the natives gave them to their children to play with. In this way, they were destroyed.

Schwatka found a number of skeletons of the Franklin party, which he buried. This was on King William's Land, southwest of Boothia.

He reports a temperature in January, 1880, of 70° below zero, and says his white men endured the cold as well as the natives, who call themselves Inuits. His course lay northwest from Hudson bay. The party killed 511 reindeer.

**Lieut. De Long,** in the steam cruiser, *Jeannette*, which was fitted out by James Gordon Bennett, entered the Arctic ocean by way of Bering strait. After two years, in which the party suffered greatly, the *Jeannette* was crushed in the ice and sunk in the Arctic, over 400 miles from the coast of Siberia, June, 1881. Some of the party, in an open boat, entered the Lena river and were rescued. De Long with a number of his men reached the shore, but perished from cold and hunger on the frozen wilds of Siberia. Others of his party have never been heard from. De Long discovered three small islands, which he named Bennett, Henrietta, and Jeannette.

**The International Polar Conference** was organized by the exertions of the late Lieutenant Karl Weyprecht, for the purpose of establishing a chain of stations around the north pole, at points as far north as possible. These stations were for the purpose of investigating the meteorology of the north polar regions. A uniform system of taking meteorological pendulum, magnetic, tidal, and other observations was adopted by the commission.

The Russian government established two stations, one at the mouth of the Lena and the other on New Siberia island; Norway, a station at Boskopen, in Finmark; Sweden, one in Spitzbergen; Holland, one on the Gulf of Obi; Denmark, one at Upernavik; the Austro-Hungarian Monarchy, one at Jan Mayen island; and the United States two, one at Point Barrow and one at Lady Franklin bay.

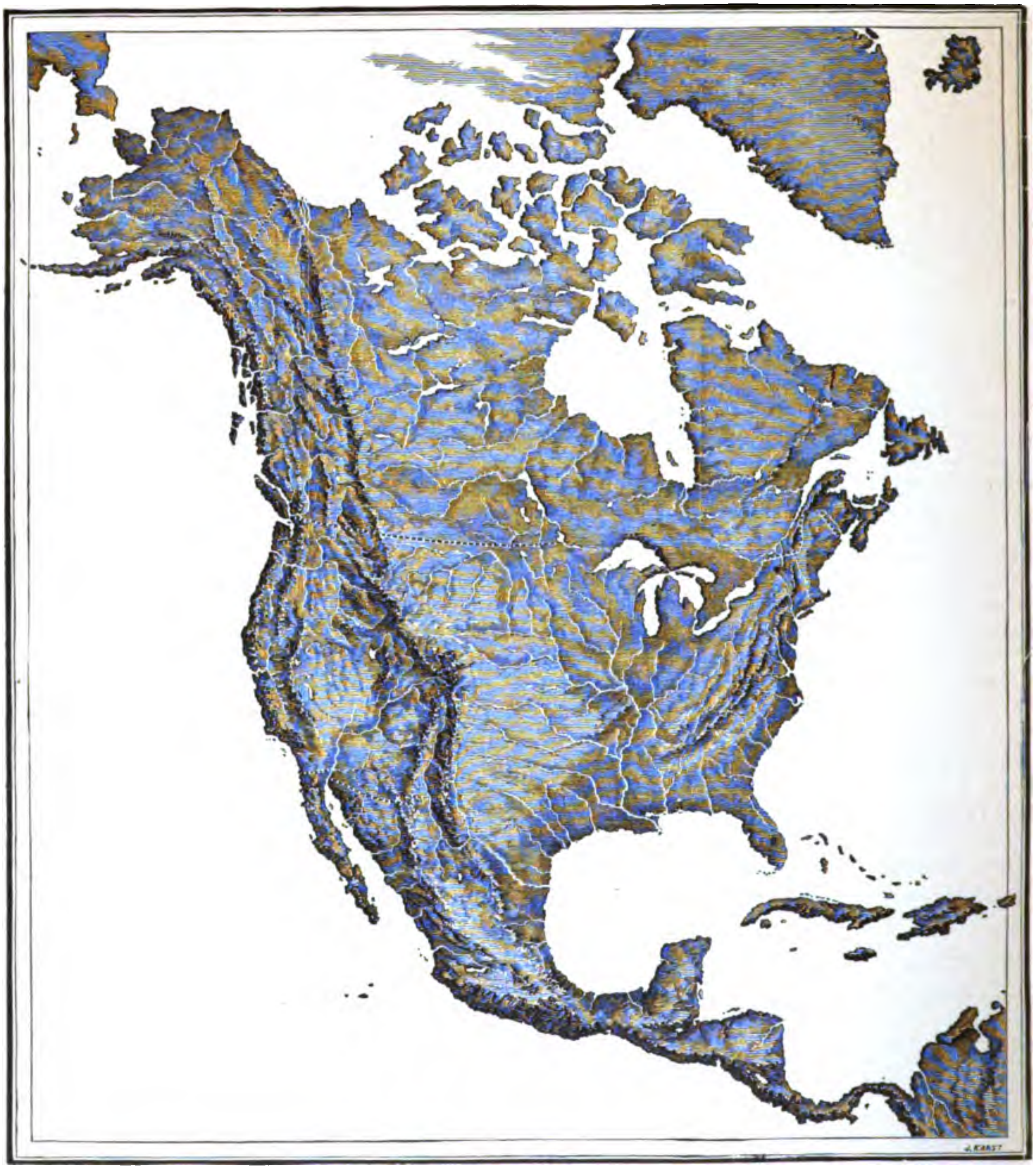
The Point Barrow party reached their destination in July, 1881, in command of Lieut. Ray, for many years in the U. S. Signal Service, and remained in Alaska until 1884. During this time, a large number of observations were effected, successful explorations of the northwest coast were undertaken, and many important discoveries were made concerning the topography, zoology, and meteorology of Alaska.

The Lady Franklin bay party proceeded to a small established station at a place where a coal-bed had been discovered by the Nares expedition. The party was in command of Lieut. (now Brevet-Major) Arthur W. Greely, whose twelve years' service as meteorologist in the U. S. Signal Service had especially qualified him for such an undertaking. The party were conveyed north of Smith Sound and landed at Lady Franklin bay in August, 1881. A station was established on the north shore of the bay named Discovery Harbor.

Major Greely explored the interior, in the vicinity of Lady Franklin bay. Several large lakes and mountain ranges were surveyed. The highest point of land in one of these, the United States Range, was named Mount Arthur.

The highest temperature recorded was 52° F., the lowest, —66° F., during which time the mercury remained frozen for 15 consecutive days.[1]

[1] Mercury freezes at —37.9°.



Relief Map of North America.

## Chief Mountain Systems.

ROCKY, APPALACHIAN.

### Highest Peaks.

| | | | |
|---|---|---|---|
| Mt. St. Elias | 19,500 ft. | Mt. Brown | 15,900 ft. |
| Vol. Popocatepetl. | 18,500 ft. | Mt. Hooker | 15,675 ft. |
| Vol. Orizaba | 17,374 ft. | Mt. Whitney | 15,086 ft. |

### Principal Lakes.

| | | | |
|---|---|---|---|
| Superior, | Great Slave, | Michigan, | Erie, |
| Great Bear, | Winnipeg, | Ontario, | Huron. |

## Drainage Systems.

| BASIN OR SLOPE. | RIVERS. |
|---|---|
| MISSISSIPPI BASIN | Mississippi and tributaries. |
| ST. LAWRENCE BASIN | St. Lawrence and tributaries. |
| ARCTIC SLOPE | Mackenzie and tributaries. |
| HUDSON BAY BASIN | Nelson, Churchill, and others. |
| GREAT BASIN | Colorado and tributaries. |
| PACIFIC SLOPE | Columbia, Yukon, San Joaquin, and tributaries. |
| ATLANTIC SLOPE | Numerous short rivers. |

The displays of the northern lights were generally fair, but not to be compared in brilliancy with those frequently observed at Disco island, Upernavik, and localities further south. There was no crackling sound accompanying the auroral display, and, contrary to expectations, the electrometer, an instrument designed to show the presence of electricity, gave not the slightest result.

The highest barometer observed was 31.05 inches, and the lowest, 28.95 inches. This range, 2.1 inches, seems a great one for high latitudes, and shows that general atmospheric movements are nearly as great there as in the tropics where they originate. The highest velocity of wind recorded was seventy miles an hour.

The tidal observations revealed some startling facts. At Lady Franklin bay, the tides came *from the north*, but at Cape Sabine and Melville Bay the wave came *from the south*. The water of the flowing tide at Discovery Harbor was somewhat warmer than that of the ebbing tide. The average temperature of the sea water at Lady Franklin bay was 29° F., being three degrees below the freezing point of fresh water.

The observations in magnetism were complete and interesting. The results show that in that latitude, the magnetic needle is constantly in a tremor, except during severe storms, when it becomes quiet. At Lockwood and Brainard's furthest point north, the needle varied 104 degrees, or more than a quarter of a circle from the true meridian.

The furthest point north reached by Lieut. Lockwood and Sergt. Brainard was latitude 83° 24′, the highest ever attained by man. Fifteen miles above this point, a high promontory was discerned, which was named Cape Robert Lincoln. Not only did Lockwood and Brainard reach the highest latitude, but they explored the northern coast of Greenland 150 miles farther eastward than had ever before been trodden by man.

This party left Lady Franklin bay in August, 1883. When opposite Cape Sabine, they were compelled to abandon the small steam launch, and for thirteen days, during a terrible storm, drifted helplessly on an ice pack. After great suffering, they reached land and proceeded to Cape Sabine, where they built winter quarters. Here they remained from September, 1883, until July, 1884. Their supply of food became exhausted, and the party suffered horribly during their encampment at this place. All but nine of the party perished from exposure and starvation.

In the meantime, Commander Schley had been ordered to proceed in search of the party, and with three steam vessels, the *Thetis*, *Bear*, and *Alert*, he reached Cape Sabine, in eighteen days from time of leaving Upernavik—a feat unparalleled in the annals of Arctic exploration.

The results attained by the observations of Major Greely and Lieut. Ray have given the world more knowledge concerning the meteorology of the polar regions than those of all other expeditions combined. This is due, not only to the thorough training of the officers and men in charge, but also to the system and skill with which the observations were taken and their mutual relations considered.

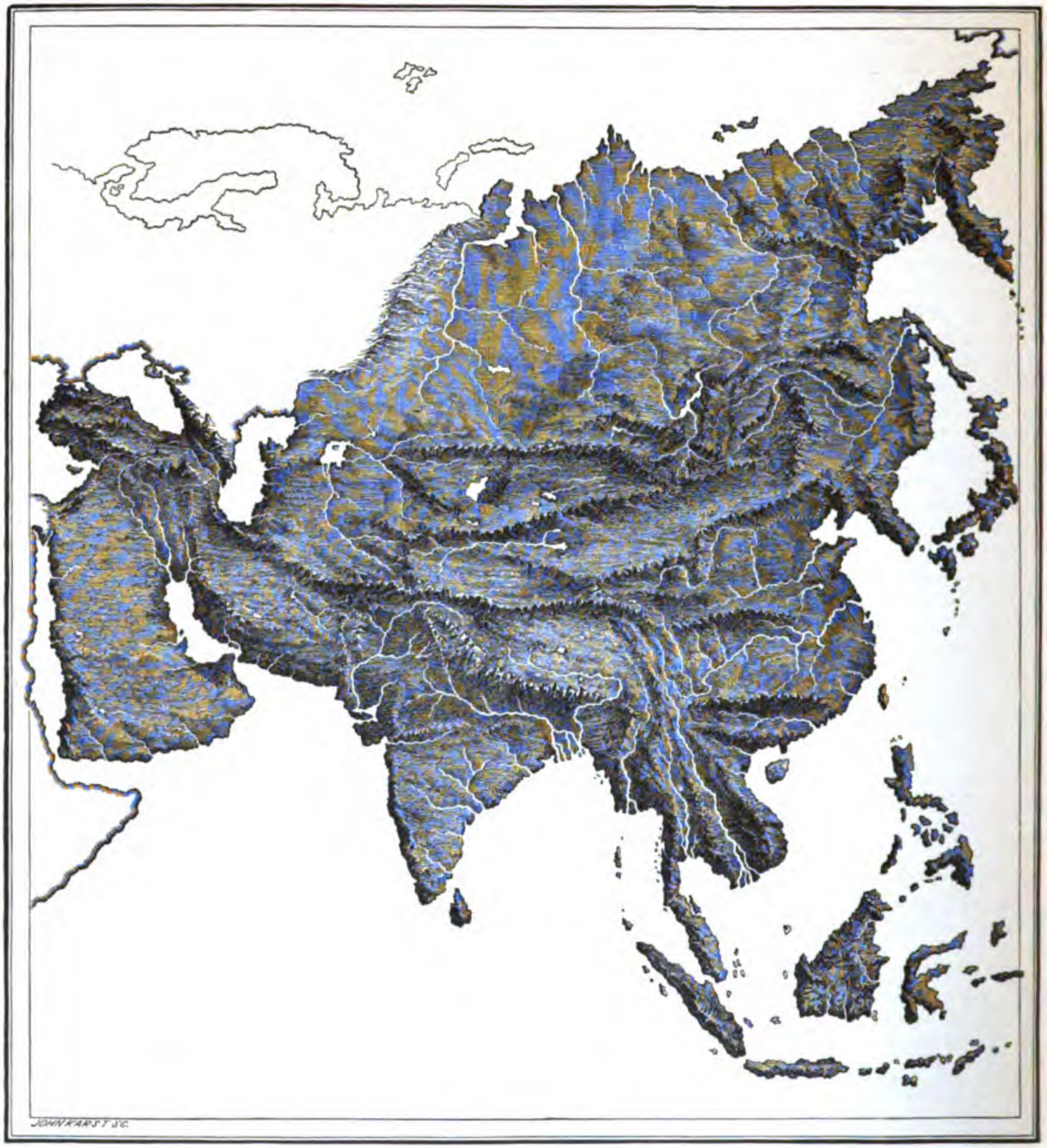
**Ocean Hydrography.**—The surveys made by the Coast Survey Steamer *Blake* in the Gulf of Mexico and along the eastern coast of the United States, have established a number of facts quite contrary to those hitherto asserted.

The contour of the bed of the gulf reveals the existence of a succession of terraces or steps, of uniform width and depth, extending around the gulf somewhat like the rows of seats in an amphitheater. The first of these terraces varies from thirty to one hundred miles in width, on which the depth of water is less than 500 feet. Then the bottom slopes quite abruptly to the next terrace, on which the water has an average depth of 2,500 feet. This terrace is a narrow one, not more than twenty or thirty miles wide. The slope to the next terrace is likewise quite steep, on which the average depth of water is about 4,000 feet. The descent to the next terrace is still more abrupt, and the depth of water thereon is about 10,000 feet. This terrace is about one hundred miles wide and tolerably uniform in width. The lowest part of the bed is in the center of the gulf, and the water here has a depth of about 12,000 feet. The deepest sounding reached is 2,119 fathoms, or 12,714 feet.

Between Florida and Yucatan, is a submarine ridge on which the depth of water nowhere exceeds 6,000 feet. From the lowest summit of this ridge, the island of Cuba rises with almost precipitous walls. Within five miles of either of the Cuban shores, the depth of water is nearly 6,000 feet, while the slopes towards Yucatan and Florida are uniform and gentle. On these ridges, the temperature of the water obeys the law of temperature, decreasing uniformly to the bottom. Within the gulf, this is not the case. Here the temperature decreases until the depth of water on the ridge is reached, below which the temperature is uniform. That is, no colder water enters the gulf than that which is found on the ridge.

The movements of water within the gulf are found to be irregular, and governed to a great extent by the wind. Along the northern shores, there is generally an eastward drift of water caused by the prevailing winds. At times, this drift is not only arrested, but occasionally reversed. The surveys of Commander Bartlett show conclusively that not only has the drift of the gulf no connection with the Gulf Stream, but also that the waters of the Gulf Stream do not enter the Gulf of Mexico. On the contrary, no water of the Gulf Stream passes further west than Florida strait.

Commander Bartlett's surveys along the eastern coast of Florida also demonstrate that the Gulf Stream, instead of flowing upon a bed of cold water—an opinion which has obtained for many years—really extends to the bottom, and in many places, flows with a velocity sufficient to sweep it bare of ooze. In most localities, the bottom is strewn with minute shells brought from the Caribbean sea. In the vicinity of Hatteras inlet the bottom is covered with shells or skeletons of organisms brought by the Arctic current, which, at this locality, is an undercurrent. Opposite Charleston, there is a




Relief Map of Asia

## Chief Mountain Systems.

HIMALAYA, STANOVOY.

## Highest Peaks.

| | |
|---|---|
| Mt. Everest......29,000 ft. | Mt. Choumalarie...23,929 ft. |
| Mt. Kunchinginga..28,178 ft. | Mt. Ararat.........17,210 ft. |
| Mt. Dhawala-giri,..28,000 ft. | Mt. Sinai.......... 7,497 ft. |

## Lakes and Inland Seas.

| | | | |
|---|---|---|---|
| Caspian, | Aral, | Dead, | Baikal, |
| Balcash, | Bouka, | Lop, | Koko. |

## Drainage Systems.

| BASIN OR SLOPE. | RIVERS. |
|---|---|
| ARCTIC SLOPE............... | Obi, Yenisei, Lena, and others. |
| PACIFIC SLOPE.............. | Amoor, Hoang, Yang-tse, and others. |
| INDIAN SLOPE. .............. | Indus, Ganges, Irrawaddy, and Cambodia. |
| CENTRAL STEPPE REGIONS...... | Cashgar and others. |
| SYRIAN BASIN................. | Tigris, Euphrates. |

strong and well-known surface current from the north, to which the name of "Little Hell" is given on the pilot charts. After flowing on the surface for about one hundred miles, it disappears. This phenomenon is believed by Commander Bartlett to be due to the rising of the Arctic current to the surface.

**Dr. W. H. Dall,** of the Coast Survey, on investigating the currents of Bering sea, has likewise shown that many of the popular opinions concerning them are erroneous. The opinion has hitherto prevailed that the Kuro Siwo, or Japan Current, forked near the southern extremity of Kamtschatka, the main branch being deflected to the western coast of North America, while a smaller branch passed through Bering strait, where "its benign influence is felt in tempering the northwestern coast." After three years of observations, conducted under the most favorable circumstances, Dall finds that no current of water enters the Arctic ocean through Bering strait, and that the only current manifest, is a feeble, cold current from the Arctic ocean. North of the strait, the only movements are drifts which are caused by the winds. The prevailing direction of the drift is to the west or northwest, as was illustrated by the *Jeannette*, which, nipped by the ice near Herald island, was carried to a point nearly opposite the mouth of the Lena river.

**Physiography of Greenland.**—Prof. Nordenskjold, already famous for various and successful Arctic explorations, has recently penetrated the interior of Greenland to a distance of about 100 miles, greatly increasing our limited knowledge of that island. Up to the time of Nordenskjold's expedition, it had been believed by many that a large and fertile plateau covered with vegetation existed in the interior of Greenland.

It has been long known that nine centuries ago,[1] Norwegian navigators were well acquainted with the coast of Greenland and that flourishing colonies were planted there. Two hundred years afterward, the connection of these colonies with the mother country was severed. Since that time, the fate of the colonists is unknown. Whether they had been exterminated by the Esquimaux, or absorbed by them, or whether climatic changes fatal to the colonists had taken place, were questions that Nordenskjold determined to learn by a visit to the interior.

Two days after leaving Reikiavik, Iceland, the eastern shores of Greenland were seen. After steaming along the coast for several days, unsuccessful in finding a place for landing, the *Sophia* was headed for Disco bay on the western coast. Here, Nordenskjold with his sledge party landed, and arranged the details of the expedition. Nine sturdy Lapps were selected, sledges were constructed, and the necessary apparatus for scientific observations were put in order for use.

The expedition proceeded in a boat up a small stream flowing into Disco bay. After four days, the boat was abandoned and the sledge journey begun. The ice was so furrowed by crevasses that it was impossible, at times, to advance more than three or four miles a day. After reaching a distance of about 100 miles inland, Nordenskjold sent a party of Lapps ahead about 70 miles. They made the trip on *skidors*, or snow shoes resembling sled runners, requiring but 57 hours for the whole distance. During this time they slept but four hours. At this distance, there was no sign of land; nothing could be seen but snow and ice. The height, as recorded by aneroid barometers, was a little less than 7,000 feet, and the altitude was still increasing towards the east.

During the entire trip, but few signs of life were visible. A small worm which lives on ice *algæ*, and a few birds only, were observed. The birds, with the exception of two ravens, were water fowl. The latter were returning from the north. The only vegetation observed consisted of the various species of algæ, which give their peculiar color to the snow. These are, in most cases, microscopic in size, and are the cause of the red appearance of the snow occasionally observed in high latitudes.

One of the most interesting features noticed was the existence of a peculiar "dust," or finely-divided mineral substance, which seemed to cover the whole interior of the island. From the manner in which it is distributed, it is impossible that it should be native to the island. On the top of snow, which was still soft, the dust was evenly deposited. Wherever the temperature was above the melting point, the dust had melted it away just beneath the surface. Along the glaciers, the water had frequently collected large quantities of it in pools. The chemical composition of this substance closely resembles that of meteorites, and contains a large percentage of metallic iron and nickel. The dust was entirely free from sand or mud of sedimentary origin, and was without doubt deposited there through the agency of the winds. Nordenskjold has given it the name of *Kryokonite*.

After returning to the coast, the expedition re-embarked on the *Sophia* and again proceeded to the eastern coast of the island. This time, Nordenskjold succeeded in effecting a landing—the first made south of the Arctic circle, for several centuries. Here were discovered a few ancient ruins, the only traces of the former settlements seen during the expedition.

During the voyage along the coast, soundings and dredgings were made on all possible occasions. A large number of temperature measurements, made with the most approved apparatus, "demonstrate that the cold current running along the east coast is, both in width and depth, very insignificant, and rests even near the shore upon a current of warm water produced by the Gulf Stream. Davis Sound and Baffin Bay, on the other hand, are filled with cold or very slightly warmed water *to the bottom*. Contrary, therefore, to the general belief, *the west coast of Greenland is washed by cold water, while a greatly heated current coming from the south runs along the east coast a distance of only 40 or 50 miles from the shore.*"

[1] Greenland was discovered by Erik Rode before the year 1000.


Relief Map of Europe.

## Chief Mountain System.

ALPINE.

## Secondary Systems.

Scandinavian, Ural.

## Other Ranges.

| | | |
|---|---|---|
| Cantabrian, | Apennines, | Valdai Hills, |
| Carpathian, | Cau'casus, | Sierra Nevada, |
| Balkan', | Pindus. | |

## Highest Peaks.

| | | | |
|---|---|---|---|
| Mt. Elboorz | 17,796 ft. | Mt. Cervin | 14,771 ft. |
| Mt. Blanc | 15,810 ft. | Mt. Pelvoux | 14,108 ft. |
| Mt. Rosa | 15,208 ft. | Finister Aarhorn | 14,026 ft. |

## Drainage Systems.

| BASIN OR SLOPE. | RIVERS. |
|---|---|
| BLACK SEA BASIN | Don, Dnieper, Danube, and others. |
| CASPIAN SEA BASIN | Volga, Ural, and others. |
| BALTIC AND NORTH SEAS BASIN. | Duna, Vistula, Oder, Elbe, Weser, Rhine, and others. |
| MEDITERRANEAN SEA BASIN | Rhone, Ebro, Po, Tiber. |
| ARCTIC SLOPE | Petchora, Dwina, Mezene. |
| ATLANTIC SLOPE | Seine, Douro, Loire, Tagus Garonne, Guadiana. |

## Lakes.

Lad'oga, Onega, Geneva, Como, Elton, Wener, Wetter.

Relief Map of South America.

### Chief Mountain Systems.

ANDEAN, BRAZILIAN.

### Highest Peaks.

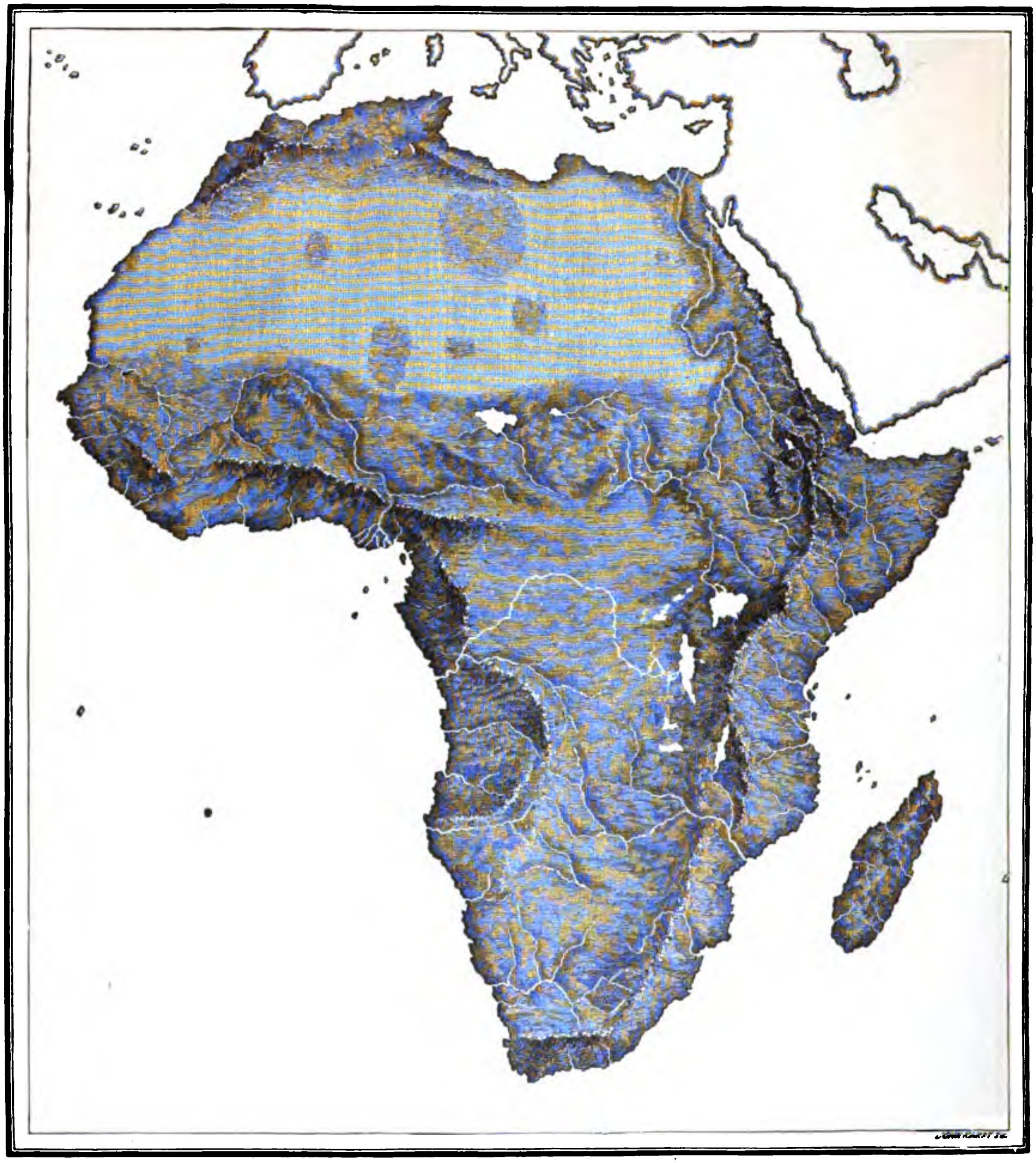
| | | | |
|---|---|---|---|
| Mt. Aconcagua | 23,900 ft. | Mt. Chimborazo | 21,424 ft. |
| Mt. Sahama | 22,350 ft. | Mt. Sorata | 21,286 ft. |
| Vol. Gualatieri | 22,000 ft. | Mt. Illimani | 21,149 ft. |

### Lakes.

Maracaybo. Titicaca.

### Drainage Systems.

| BASIN OR SLOPE. | RIVERS. |
|---|---|
| ORINOCO BASIN OR VALLEY | Orinoco and tributaries. |
| AMAZON VALLEY | Amazon, Tocantins, and tributaries. |
| N. E. ATLANTIC SLOPE | San Francisco and others. |
| LA PLATA VALLEY | La Plata and tributaries. |
| S. E. ATLANTIC SLOPE | Colorado, Nero, and others. |
| PACIFIC SLOPE | Numerous short rivers. |



**Relief Map of Africa.**

## Chief Mountain Systems.

CHAIN ALONG E. COAST (no name). KONG.

### Highest Peaks.

| | |
|---|---|
| Kenia (E. Africa)...20,000 ft. | Abba Jared (Abys'ia) 15,000 ft. |
| Kilima Njaro " ...18,500 ft. | Teneriffe (N.W. Afr.) 12,182 ft. |
| Gambaragara (C. Af.) 18,500 ft. | Miltsin (Morocco)....11,400 ft. |

### Lakes.

| | | | |
|---|---|---|---|
| Victoria, | Albert, | Tanganyika, | Nyassa, |
| Lincoln (?), | Moero, | Bangweolo, | Tchad. |

## Drainage System.

| BASIN OR SLOPE. | RIVERS. |
|---|---|
| NILE BASIN.................... | Nile and tributaries. |
| CENTRAL BASIN................ | Congo and tributaries. |
| NORTH ATLANTIC SLOPE........ | Senegal and others. |
| NIGER BASIN.......... ....... | Niger and tributaries. |
| SOUTH CENTRAL BASIN......... | Zambeze and tributaries. |
| INDIAN SLOPE................. | Numerous short rivers. |
| NORTH CENTRAL STEPPE....... | Several short rivers. |